DAYLIGHTING RIVERS
SCIENCE EDUCATION FOR CIVIC ECOLOGY

Co-funded by the Erasmus+ Programme of the European Union

Proceedings of the International Conference

Daylighting Rivers: Inquiry Based Learning for Civic Ecology

Florence
1-2 December 2020

Edited by
Ugolini F. & Pearlmutter D.

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Preface

This conference represents the final event of the *Daylighting Rivers* project, which has engaged secondary school students in inquiry-based and interdisciplinary learning focused on land and river use and transformations, with an emphasis on the ways in which urban growth impacts local river ecosystems.

Three pilot schools in Europe successfully implemented this approach, involving more than 200 students in the application of learning units developed within the project to investigate different aspects of their local rivers, from biodiversity to environmental threats.

In its second phase, the project engaged additional schools who overcame the obstacles of time and COVID-19 to participate in the International Competition "Schools in Action for Daylighting Rivers". This competition has brought together groups of students eager to discover the rivers of their local area, inspiring global action for sustainability. Among the highlights of the conference were the presentations of these student projects, and the announcement of the competition prize winners at the final Award Ceremony.

This conference also showcases contributions from stakeholders involved in a variety of sectors related to river studies and management. In the sessions described below you will see a great diversity of speakers, presenting scientific and professional case studies in fields ranging from innovative education methodologies, gamification and the use of digital technologies to citizen science and river management and restoration.

All of the materials produced during the project, as well as the conference presentations, are accessible on the project's website: *www.daylightingrivers.com*.

Vincenzo Striano
WERF - Coordinatore didattica, relazioni istituzionali e territoriali
Daylighting Rivers Project Coordinator

Scientific committee:

Education:

Bulent Cavas, President of the International Council of Associations for Science Education, UK; Professor at the Science Education Department of the Dokuz Eylül University, TK

Elvira D'Ambrosio, Head of the High School Sensale, IT

Karl Donert, Vice President EUROGEO; Vice President, Council of Europe INGO Conference, Commission on Education and Culture; Director European Centre of Excellence, digital-earth.eu; University of Salzburg, Salzburg Austria; Director Innovative Learning Network Ltd.

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Lina Marrazzo, Professor at the High School Sensale, IT

Luciano Massetti, Researcher at the Institute of BioEconomy – National Research Council, IT

Yasemin Özdem Yilmaz, Assistant professor at the Department of Primary Education, Mugla Sitki Kocman University, TK; Executive Committee Member, Secretary of the International Council of Associations for Science Education, UK; Executive Committee Member, International Relations Coordinator of the Turkish Science Education and Research Association, TK.

Pilar Parras Masa, Professor at the High School Espinosa, ES

Claudia Polverini, Italian Association of Natural Science Teachers - President of the Florence section

Sandro Sutti, Co-founder of the Regional Centre for Environmental Education (Labter-Crea rete di Scuole); Coordinator of Global Rivers Environmental Education Centre and GLOBE-Italy, IT

Andrea Theofilou, Professor at the Rafina Lyceum, GR

Francesca Ugolini, Researcher at the Institute of BioEconomy – National Research Council, IT

River use, quality and restoration, land use studies and planning:

Gonzalo Barbera, Researcher at the Department of Soil and Water Conservation - CSIC-CEBAS, ES

Enrica Caporali, Professor at the Civil and Environmental Engineering Department - University of Florence, IT

Serena di Grazia, President of Association Maieutiké, IT

Francesc Gallart, Surface Hydrology and Erosion Group, Institute of Environmental Assessment and Water Research (IDAEA-CSIC)

Mauro Grassi, Struttura di missione contro il dissesto idrogeologico e per lo sviluppo delle infrastrutture idriche, IT

Eduardo Lafuente, Segura Basin Water Authority, ES

Demetris Mylonas, PRISMA Centre for Development Studies, GR

Marc Nuara, Science and technical Manager at the River Restoration Centre, UK

Fouli Papageorgiou, Managing Director and Partner of PRISMA Centre for Development Studies, GR

David Pearlmutter, Professor at the Department of Geography, Ben Gurion University, IL

Vincenzo Striano, Coordinator of studies and institutional and territorial relations, Water Right Foundation, IT

Fabrizio Ungaro, Researcher at the Institute of BioEconomy – National Research Council, IT

Organizing committee

Vincenzo Striano, Water Right Foundation, IT (Project Coordinator)

Serena di Grazia, Water Right Foundation, IT (Secretariat)

Maria A. Liberti, Institute of Atmospheric Pollution Research - National Research Council, IT (Web Master)

David Pearlmutter, Department of Geography – Ben Gurion University, IL (Editor)

Francesca Ugolini, Institute of BioEconomy – National Research Council, IT (Secretariat)

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Introduction

DAYLIGHTING RIVERS
SCIENCE EDUCATION FOR CIVIC ECOLOGY

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SCIENTIFIC AND ENVIRONMENTAL EDUCATION IN THE SERVICE OF OUR RIVERS

Ugolini F.[1], di Grazia S.[2], Striano V. [2], Pearlmutter D. [1,3]

[1]Institute of BioEconomy, Sesto Fiorentino, Italy francesca.ugolini@ibe.cnr.it;
[2]Water Right Foundation, Firenze, Italy, geol.digrazia@gmail.com, v.striano@wrf.it
[3]Department of Geography and Environmental Development, Ben-Gurion University of the Negev, Sede Boqer Campus, Israel, davidp@bgu.ac.il

Since humans first appeared on earth, one of the essential conditions for basic survival has been our close relationship with *water*. Not by chance, all of the ancient civilizations known to history developed along rivers: the Sumerians (5500-4000 BC) between the Tigris and Euphrates in Mesopotamia, the Egyptians (3100-500 BC) along the Nile, the Indus valley civilization (2600-1900 BC) along the Indus river and its tributaries, and the Romans (753 BC - 476 AD) along the banks of the Tiber. Rivers were a direct source of life by providing water and food, and they also served these societies indirectly by allowing agricultural land to be irrigated and livestock watered.

Figure 1. Ancient Egyptian fresco from the Tomb of Nebamun (c. 1350 BC), depicting life along the Nile river.

These rivers were also invaluable as transportation routes, providing vital arteries for trade and cultural exchange – and in many cases they even acquired spiritual significance, holding symbolic value connected to the cycle of birth, life and death. In Mesopotamia it was believed that the fresh waters of an immense subterranean ocean were protected by the god Apsu; the ancient Egyptians revered Nephthys as the goddess of the rivers along with numerous other Nilotic deities; in Greece Acheloo and Alfeo were divine personifications of their eponymous rivers; in India the goddess Ganga represented the river Ganges; for the Aztecs, human sacrifices had to be offered to the rain god Tlaloc to avoid dry periods and Chalchiuhtlicue was the goddess of water, rivers, lakes and seas. Water has been used as an agent of purification, not only in the physical sense but also morally and spiritually, through 'ritual baths' in the Jewish (mikveh) and Christian (baptism) as well as Hindu, Greek and pagan traditions.

While mankind has undoubtedly revered flowing rivers, many have also feared their unpredictable force. Since antiquity, hydraulic techniques have been employed to manage the control of water in response to potentially destructive seasonal events, including the containment, channeling, and lifting of the waters. These feats of

engineering allowed for greater food security, leading to the development and organization of increasingly complex and culturally advanced societies.

Figure 2. Detail of the 'Pianta della Catena' (1471-82) by Francesco di Lorenzo Rosselli, the first mapping of Fiorenza (Florence) to fully represent the city's buildings and streets – highlighting the central role of the Arno river in the life of the city.

Paradoxically, in more recent times and with much more advanced tools for forecasting and planning, many modern urban planning choices have been made with less care and foresight than those of ancient civilizations. Rivers have sometimes been exploited to the point of being reduced to negligible streams, and in some cases no longer even flow to the sea. Urban development has too often deteriorated the quality of the water, channeled rivers in lifeless canals and underground culverts, or in some cases eliminated them altogether to make room for other infrastructures.

Figure 3. A canalized stream in Follonica, Italy. How can we best resolve the convergence between the built and natural environment?

To give but one example, Florence has a total of some 30 "hidden" rivers flowing under its surface – waterways that still form an essential part of the urban drainage system, but which are visually and functionally disconnected from the landscape of the city.

Drastic management interventions such as covering urban rivers are likely to interfere with the evolutionary processes and natural functioning that allow a local ecosystem to maintain its dynamic equilibrium. This type of interference can have serious consequences, particularly in the current context of climatic disruption in which flood-inducing storms and other extreme weather events are increasingly frequent. Why amplify, rather than reduce, these risks?

Figure 4. A river runs through the urban heart of Ljubljana, Slovenia.

The potential hazards facing urban populations would indeed by lessened if planners were to consider the long-term implications as well as the immediate consequences of their decisions. The growing threat of flood damage is especially acute in cities where the presence of rivers that are buried, rectified and crossed by narrow-span bridges exposes thousands of citizens to the danger of overflow. The dramatic events of recent years seen in so many cities should make us reflect on the importance of awareness and knowledge regarding the dynamics of river ecosystems, and on the opportunities that still exist to nurture a sustainable relationship between the human being and the "river resource".

The hope of being able to cultivate a "conscious generation" urges us to focus on the involvement of young people in the rediscovery of river ecosystems – and particularly in discovering *their* rivers – and on educating future adults to apply and promote the concepts of environmental sustainability and resilience. In this sense, environmental education plays a fundamental role in allowing citizens of all ages to consider environmental issues, to engage in problem solving and to take action toward improving the quality of the environment. In order to acquire meaningful knowledge of environmental problems, it is especially useful for young investigators to understand and apply a scientific approach to empirical information – since through observation and analysis of data, they can truly investigate issues and phenomena in an objective and shared way. It is equally vital to stimulate critical thinking, inside and outside the classroom, encouraging students to learn for themselves the necessary skills to cooperate with one another and to develop their own creativity and original theories.

At the same time, conventional science education within the confines of a typical classroom environment has its limits. In contrast, learning by experiencing or observing nature directly has undisputed value for achieving personal growth, and it is no coincidence that the very methods which are considered most effective for acquiring knowledge and decision-making skills, as well as for building self-esteem, are those which make the student *agents* of their own knowledge. Approaches that are inspired by "Inquiry-Based Learning" allow the student to be at the center of the activity, and to become the creator and/or implementer of the acquired information by building the methods, analyzing the data, solving the problems and reflecting on the results.

It is in light of all these considerations that the scientific and environmental education project **"Daylighting Rivers – Science Education for Civic Ecology"** was conceived, developed and brought to fruition. Funded by the European *Erasmus+* program, the project's main objective is to lead students to a meaningful knowledge of the river ecosystem, focusing on the problems it faces and threats to its quality, as well as the functions it fulfills and the services it provides to the community. Most distinctively, to the goal is for students to understand the importance of "bringing to light" the hidden rivers that are buried under their city – in a sense that is figurative as well as tangible.

Initiated in 2018, Daylighting Rivers reached out during its first year to about 250 students from four Mediterranean countries, engaging them in a variety of teaching units on issues that deal in an integrated way with the human impact on rivers. The students took an active role in this educational process, through Inquiry-Based Learning and the encouragement of their own creative endeavors. These efforts have culminated in the development of interactive Location-Based Games by the students themselves, working in teams within the framework of an International Competition entitled “Schools in Action for Daylighting Rivers”. This competition has brought together

groups of students who are eager to discover the rivers of *their* area, tackling local problems and inspiring global action for sustainability.

Daylighting Rivers aspires, through a diversity of tools, languages and methodologies, to "rediscover" the pleasure of scientific learning – and to form an inclusive learning community that brings together students, parents, teachers, educators and researchers who care about their environment and one another. This fundamental sense of taking responsibility for one's actions, whether in the promotion of long-term sustainability or simply the common good, is what lies at the heart of civic ecology – and indeed is at the core of the Daylighting Rivers initiative.

Daylighting Rivers Erasmus+ Project

Co-funded by the Erasmus+ Programme of the European Union

DAYLIGHTING RIVERS - EUROPEAN PROJECT FOR INNOVATIVE TEACHING

Striano V.[1], Di Grazia S. [2], Ugolini F. [3]

[1]Water Right and Energy Foundation, Florence, Italy, v.striano@wrf.it
[2]Water Right and Energy Foundation, Florence, Italy, geol.digrazia@gmail.com
[3]Istituto per la BioEconomia, Sesto Fiorentino, Italy, francesca.ugolini@ibe.cnr.it

Abstract

Historically, water resources have allowed the development of urban settlements and water forms and availability - such as surface water or underground water (springs, rivers and streams, aquifers, lakes), have influenced the urban environment either in connection to danger and risk connected to the proximity of the water body, either for the functional and aesthetic value.

The educational project Daylighting Rivers -co-funded by the European Union in 2017 (Project number 2017-1-IT02- KA201-036968), takes its cue from such theme to develop a teaching methodology that aims to facilitate STEM learning and at the same time to raise teachers' and students' awareness on the importance and vulnerability of water bodies, especially in a urban context. The project was implemented in Italy, Spain and Greece, countries with similar environmental characteristics and urban sprawl processes that have been emphasizing water issues especially in time of climate change.

Over the first two years, the project involved three pilot secondary schools that tested an innovative, multidisciplinary and participatory teaching methodology, based on a model of Inquiry Based Learning. From the pedagogical point of view, the methodology fosters the students' centrality and curiosity for investigating the local river in own town or province.

Twenty learning units were developed on specific topics connected to macro-themes that can be implemented in different school disciplines. The promotion of innovative digital tools such as Location Based Games have also allowed students to approach and work with georeferenced information, but also combine technical-scientific aspects and language to historical-humanistic-artistic aspects and storytelling. Students could also reflect on a variety of aspects related to rivers in town such as social, ecological, cultural and economic well-being aspects.

Keywords: educational methodology, sustainability, urban environment, water, rivers

The Project

DAYLIGHTING RIVERS is a European project co-funded by the Erasmus+ Program which engages secondary school students in hands-on, interdisciplinary investigations of their local environment. Daylighting rivers means bringing to the light the rivers that have been hidden under concrete, and as broader meaning, it also means discovering, knowing the rivers and underlining the importance of river ecosystem. The main aim of the project was to raise students' awareness on the importance of saving and protecting river ecosystems and understanding the causes of the main threats, especially in urban environment. Central focus is on studying changes in the urban land cover, and particularly the riverways that flow through the city, with an emphasis on the ways in which urban growth and river management impact local ecosystems.

Most project partners were from three Mediterranean countries: Water Right and Energy Foundation (WERF) – as coordinator of the project, the Institute of BioEconomy (IBE-CNR) and Liceo Scientifico Sensale- Nocera Inferiore (Sensale High school) in Italy; Center for Development Studies (PRISMA) and Rafina High School (Rafina High School) in Greece; the Department of Soil and Water Conservation of the Consejo Superior de Investigaciones Cientificas (CEBAS-CSIC) and Miguel Espinosa Hight School in Spain. Then, the International

Council of Associations for Science Education (ICASE), based in England, as umbrella of organizations and schools around the world dealing with science education.

The scientific partners were characterized by multidisciplinary, with specific expertise in scientific fields related to the use of water resources, in pedagogy, but also in the use of digital tools in innovative teaching and learning. The three high schools tested the learning units and gave suggestions for implementation of the materials. The schools, teachers and students had the possibility to collaborate with scientists and experts, inside and outside the project partnership, in the professional fields related to the project themes, strengthening also the connection with stakeholders of the territory.

The project was organized into five actions providing Intellectual Outputs, each of them was the basis outcome for the following action. The table below summarizes the main actions and the responsible partner.

Table 1. Project actions and Intellectual Outputs

Action	Intellectual Outputs	Referent partner
IO1	Identification of the students' skills and competences in relation to the thematic of the project.	PRISMA (GR)
IO2	Definition of the IBL methodology outline	IBE-CNR (IT)
IO3	Development of the Learning Units	CEBAS-CSIC (ES)
IO4	Application of the modules in the school	Sensale HS (IT)
IO5	Evaluation of the methodology and Learning Units and assessment of the intervention's efficacy	ICASE (UK)

The participatory atmosphere and the interdisciplinary work triggered an effective synergy that produced a rich collection of high-quality materials. The partners' staff showed active participation since the beginning of the project and it was involved, although at different extent, in various actions with brainstorming meetings and operational activities, such as for the creation of educational materials. Management was organized at two levels: the overall project management and at national level with scientific partners supporting the schools and coordinating the project progress. Following this structure, also it was easy for the schools to participate in all the actions of the project.
The teachers of the partner schools were trained in Italy in a five-day training course, focused on the use of technologies for territory studies (Geographic Information Systems and Location Based Games). Training materials, developed by experts on such topics, include practical examples and step-by-step guidelines and are available for any trainees like teachers or educators in general.
The project also has developed an educational methodology that was used for structuring teaching materials (learning units) on urban rivers.

Methodology and Learning Units

The main issue of the project was to developed a specific methodology aimed to place the at the center of the learning experience, with direct and practical experiences. The methodology is based on the steps of Inquiry Based Learning which nurtures students to be responsible for their own learning process (Ugolini et al. 2018, 2020; Pedaste et al. 2015; Kaltman 2010), enhances their interest in science (Bruder and Prescott 2013) and in problem solving in relation to environmental or learning process issues (Kaltman 2010), and makes it easier for them to envisage of a science-related future career (Di Fabio et al. 2013). The methodology is fully described in the methodology guide (Ugolini et al. 2018).
Pedaste et al. (2015) found that different descriptions of inquiry cycles in the research literature use various terminologies to label phases that are very similar. These authors summarize the Inquiry Based Learning phases from different frameworks into 5 phases: Orientation, Conceptualization, Investigation, Conclusion and Discussion.

DAYLIGHTING RIVERS has developed Learning Units structured on the Pedaste model because of its flexibility and suitability to different kinds of Learning Units and school subjects, besides the more traditional STEM, such as economy and literature. The following figure summarizes the basic structure of a learning unit whose implementation follows the cyclic model, likely leading to further investigations.

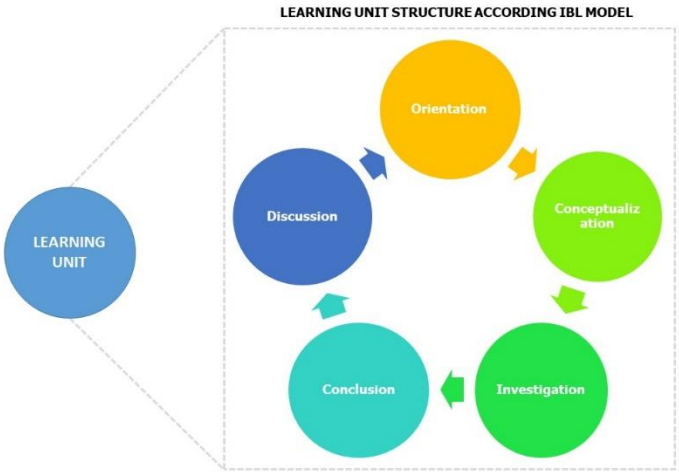

Figure 1. Phases of the learning Pedaste model within the Learning Unit

The implementation of the methodology is embodied in 20 Learning Units. The learning units are grouped into five different macro-themes related to urban rivers: “water cycle”, “impacts of human intervention on river ecosystem”, “hydrogeological risk”, “river management” and “climate change”.
People are strongly tied to the landscape with emotions (Davidson et al., 2009) that increase interest and awareness for landscape studies, regardless of their age. Indeed, rivers have a strong imprint on the territory and historical importance. Understanding the dynamics of interaction between man and nature is useful for developing a critical appreciation of rivers and their many aspects the topics, and this can be accomplished through comparison between the different ways that people have responded to changes in the river system at different times (e.g. in the past and in the present).
Although usually the learning units refer to site-specific water courses, they allow the understanding of complex systems (e.g. river ecosystem, soil properties, effects and impacts of land use, river etc.) as the rivers regulate entire river basins and its dynamics, but also of the fluvial dynamics as well as the technological, economic and social influence of civilization on water courses. The river reaction to human actions offers insights for the analysis of nature and man. Studying the river makes possible new knowledge to raise, like the history of the landscape and the culture of a place.
The learning units include different pedagogical methods such as brainstorming activities, debating, scientific investigations including hands-on activities, laboratory experience, digital tools etc., to allow students to construct their knowledge, critical thinking and also raise their environmental awareness.
Another important aspect that DAYLIGHTING RIVERS is the use of technologies for studying, investigating and communicating the project results and knowledge acquired during the project.

The Location Based Game (LBG) for innovation

One of the innovative aspects of the project is the use of Geographic Information System (GIS) and Location Based Games (LGB) software. After the application of the Learning Units in the classrooms, the students are encouraged to use specific software to publish in a creative form or represent and analyze the considerations resulting from the Learning Units with geographical techniques and tools as LGB and GIS creating own maps.
The feature that makes Geographic Information Systems (GIS) particularly interesting to educators is its ability to dynamically represent the world and its issues from a variety of spatial perspectives (Audet and Paris 1997).

Fitzpatrick and Maguire (2000) describe GIS as a set of integrated software programs designed to store, retrieve, manipulate, analyze and display geographical information. This definition underlines the possibility of operating, adding, superimposing and highlighting information related to the territory. It might seem like a pure mathematical operation but it is possible to create a map that describes the result of personal considerations of the student who has evaluated what data to enter, how to process them and how to represent them.
Location-based gaming offers great educational possibilities, as it allows educators and facilitators of learning to create constructivist experiences rich in educational content (Papageorgiou et al. 2015a, 2015b). The student's experience is not only related to the augmented reality -in which the student interacts with georeferenced virtual contents in a real space, but it has more to do with the game design. In such project, LBG have been developed by the students (Fig. 2). This means transforming the acquired knowledge into a narrative (storytelling) with creative contents occurring along a route. The logic thought and creativity together with the game mechanics make the game a tool for discovering places and share information, stories and emotions about specific stops. In facts, urban rivers can trigger social, historical, ecological considerations.

Figure 2. Work in progress for the production of LBG. Selected image from a presentation by Espinosa High School in Murcia (ES).

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After the testing of the teaching materials, local dissemination campaigns were launched in each country to promote the materials and the experiences. Other schools were invited to apply the methodology by participating in the international competition "Schools in Action for Daylighting Rivers". The award ceremony of the winners has been hosted at the international conference "Daylighting Rivers: Inquiry Based Learning for Civic Ecology". This is the dissemination event in which the educational products of the project are presented at European and international level.

Conclusions

Knowledge of science and the territory is essential to prepare students to become actively engaged and responsible, creative and innovative citizens, able to work collaboratively to overcome the complex challenges they will face. This helps us to guide technological development and innovation, to foresee and plan for the future while respecting the natural environment. Knowledge brings value and the project showed that at the end of the courses rushed by the classes there was an increase in the interest of the students and teachers who participated.

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DAYLIGHTING RIVERS PROJECT METHODOLOGY FOR INQUIRY BASED LEARNING

Ugolini F.[1], Barbera G.G.[2], Cavas B.[3,4], D'Ambrosio E. [5], Di Grazia S. [6], Germán Escudero M. [7], Marrazzo L. [5], Massetti L.[1], Mylonas D. [8], Ozdem-Yilmaz Y.[2,9], Papageorgiou F.[8], Pearlmutter D.[10,1], Ungaro F.[1], Striano V.[6]

[1]*Institute of BioEconomy, Sesto Fiorentino, Italy francesca.ugolini@ibe.cnr.it;*
[2]*Department of Soil and Water Conservation, CSIC-CEBAS, Murcia, Spain,*
[3]*International Council of Associations for Science Education (ICASE) - UK*
[4]*Dokuz Eylul University, Izmir, Turkey*
[5]*Liceo Scientifico "N. Sensale", Nocera Inferiore (SA), Italy,*
[6]*Water Right Foundation, Firenze, Italy*
[7]*IES Miguel Espinosa, Murcia, Spain*
[8]*PRISMA, Athens, Greece*
[9]*Mugla Sıtkı Koçman University, Muğla, Turkey*
[10]*Department of Geography, Ben-Gurion University of the Negev, Israel*

Abstract

The European project Daylighting Rivers, co-funded by the Erasmus+ Programme, aimed at raising students' awareness and interest toward STEM (Science, Technology, Engineering and Math) in secondary education, by making connections between the school curriculum and the local territory on issues connected to rivers – with special emphasis on urban rivers – in Italy, Greece, Spain and Turkey. In order to raise awareness of appropriate urban planning, which recognises the importance of open rivers, a series of scientific inquiry activities was developed by teams of scientists and teachers to investigate different aspects connected to water and river basins. Rivers located in the areas of the Daylighting Rivers partner-schools became the particular objects of investigation by the teams of students.

The methodology used in the project is based on Pedaste's model of inquiry-based learning (IBL), a flexible five-step learning cycle that engages students in multidisciplinary scientific investigation – and employs information technologies for the knowledge and the promotion of the territory. This paper describes the learning methodology that has been applied by more than 200 students in the project countries.

Keywords: ICT in education, Inquiry Based Learning, river science, secondary schools.

Introduction

Countries of the Mediterranean region present common traits due to similar environmental variables such as climate, vegetation and landforms, and also similar land use and urbanization approaches and impacts. Unrestrained urbanization in many towns has changed the course of rivers or even covered them over in order to locate neighbourhoods and new infrastructures, and it has also contributed to the sealing of productive soils. The tremendous consequences of these interventions include the reduction in water infiltration and retention, and thus in underground water recharge and quality. In Italy, for instance, about two square meters of soil are lost *every second* due to urbanization (Munafò 2019).

In addition, for the last 30 years these countries have been constantly recording evidence of climate change, with an increasing trend of extreme events like droughts and floods due to heavy rains, with impacts on living systems and in agricultural production. Human activity spurred by economic growth has affected river quality in countless urban areas, and has exacerbated environmental risks with repercussions for the local economy, environment, landscape and health.

All these issues have raised the importance of public awareness at all levels of society, regarding the causes of environmental degradation and the need to acquire a more sustainable lifestyle. Civic ecology can be of aid in raising such awareness, and the integration of these issues into the educational curriculum of the younger

generation is crucial. Equally important is "learning to learn" – to enhance critical thinking, questioning and investigation, applying a rational method to discern information in critical ways and to produce information by data collection, analysis and discussion.
River studies can be performed in a multidisciplinary way, and used as an opportunity to find connections and relationships between school subjects and to allow students to move from a condition of passive learners to active investigators. The Daylighting Rivers project promotes activities that can be integrated into different school subjects, and which relate to contexts that are familiar to the students (i.e. their neighborhood and local river, rural areas around their town). These activities encourage critical evaluation of tangible issues, such as the impact of policy choices on the economic development of the community, and stimulate student interest by drawing on their prior knowledge and associations.
Recognized as an especially effective approach to student engagement, inquiry-based learning (IBL) puts the students at the centre of the learning process and promotes scientific investigation. IBL methodologies emphasize the student's role in the learning process: students take an active role in exploring a certain phenomenon, asking questions and debating in order to enhance skills such as critical thinking, communication and collaboration. The teacher can adopt different specific methods such as brainstorming and discussion groups, and experiment by either guiding the students or leaving them free in their exploration. By engaging students in the learning process, with practical hands-on activities, understanding is more effective.
In the next chapter, we describe the step-by-step IBL methodology that has been chosen and used for the creation of the Daylighting Rivers learning materials.

Methodology

The learning methodology chosen by Daylighting Rivers for understanding river issues and anthropogenic impacts is founded on the acknowledged approach of inquiry-based learning (IBL), which focus on stimulating students' independent thinking. The operative assumption is that students learn better when they can make connections to their own personal experience and knowledge, and draw on these connections through practical activity (Dewey, 1933). The approach has been applied through a number of methodologies that vary in their details, but generally follow a common implementation process made up of a series of steps: i) defining a problem, ii) formulating a hypothesis or question about what causes it, and iii) conducting tests to verify the hypothesis or answer the question, just as scientists do. Some IBL methodologies are oriented towards a more 'guided-inquiry learning' approach, while others aim for a more authentic learning experience in which students are totally free to find answers to their questions by experimenting on their own.
Usually, IBL methodologies are structured in learning cycles (White and Frederiksen 1998; Bybee et al. 2006; Pedaste et al. 2015) and in general they are recognized as effective for enhancing students' knowledge and attitude toward science and self-confidence regarding their actual scientific abilities (Gormally et al. 2009). Most of them are structured in four or five phases, with an initial engagement activity in which a question or an issue raises the curiosity of the students. The engagement (or orientation) should stimulate questions and hypotheses that would explain the issue. The questions must be answered through the investigation, which is followed by conclusions and discussion. Daylighting Rivers adopted Pedaste's model due to its flexible description of the different phases, and the fact that it has also been applied in school subjects other than science. The methodology is described in more detail in the booklet "Learning Methodology Guidelines" (Ugolini et al. 2018), available on the project website at: https://www.daylightingrivers.com/implementation/.

Pedaste's model in Daylighting Rivers

In the Daylighting Rivers project, five main macro-themes regarding water and river issues can be investigated in depth thanks to the development of the related learning units. The macro-themes, accessible on https://www.daylightingrivers.com/macrothemes/, are:

1. The water cycle
2. The impacts of human intervention on river ecosystems
3. The hydrogeological risk
4. River management

5. Climate change

These themes can be explored by students in the local territory by adapting the activities suggested in the learning units to their own river or area. The learning units are step-by-step guided activities on specific topics, developed following the Pedaste model of IBL (Pedaste et al. 2015) and tested during the piloting phase of the project. The learning units available were developed by teachers and scientists of the partnership, and checked for clarity and consistency with the learning objectives and process, by an internal blind-review.

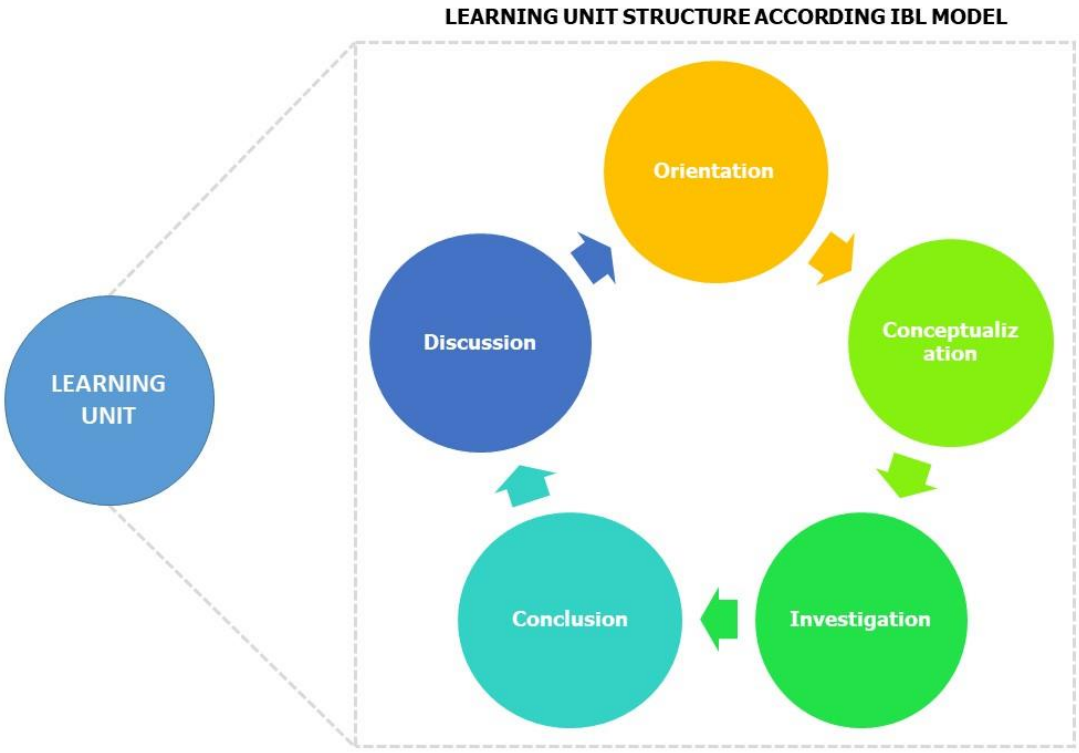

Figure 1. Phases of Pedaste's model of IBL, as used in the learning units developed in Daylighting Rivers.

The learning units are structured in five phases (as summarized in Figure 1):

1) *Orientation* is the phase in which the students' interest and curiosity "is stimulated in relation to the problem or the topic". The teacher is the facilitator of the learning process; (s)he introduces the project to the class and stimulates students to tell what they know about a local river or issue connected to water management. Students recall their prior experience, and they may express emotions and define an issue that they would like to investigate further.

2) *Conceptualization* is a process of "understanding a concept (or concepts) belonging to the stated problem". Students, with more or less guidance by the teacher, raise questions or formulate hypotheses: the reasons for a certain issue arising, why/what/how the river is exploited and managed, what is/would be the anthropogenic impact on the functions and services of a river, etc.
The questions and hypothesis are listed and might be selected in order to focus on the most relevant and feasible for the context and the available facilities. The formulation of hypothesis include thinking about the possible relationship between the observed issue and the influencing variables (Mäeots et al. 2008) (e.g. pollution types and sources, meteorology and water flow). Then, the selected questions and hypothesis are investigated in the following steps.

3) *Investigation* is the phase in which "students and teachers are in action, to answer questions and test hypotheses" (Scanlon et al. 2011). According to Pedaste, *investigation* can be further distinguished in the three sub-phases of *planning, experimenting* and *data interpretation*, as in actual scientific research.
In a river context, *planning* means defining the location(s) where the investigation will be carried out, defining what to observe and searching for information about the methods (e.g. for appropriate protocols and materials). For the logistics, the teacher will take care any organizational aspect to move the students to the location(s) and might foresee the participation of external experts to provide any additional information regarding the water management, water/land use and management along the river etc.
Experimenting means analyzing specific parameters related to environmental or management variables, and performing outdoor or indoor experiments to know more about the river.
Finally, *data interpretation* follows data analysis and relative results, in order to find the relationships between variables.

4) *Conclusion* is the phase that "gathers the results and interpretations from the investigations and experimentation". In this phase, the students integrate the knowledge acquired by different explorations and learning activities in order to get an inclusive picture of the findings related to the issue addressed.

5) *Discussion* induces students to "reflect about the findings", and often to "identify new questions to answer if the cause of a certain issue is not determined yet". *Discussion* also includes "the communication of ideas to others". Reflection is also done in terms of acquired skills, knowledge and identifying the strengths and weaknesses of the inquiry process (Lim 2004; White and Frederiksen 1998), while communication – by presenting the findings and communicating verbally to others – is a way to articulate and confirm one's own understanding (Bruce and Casey 2012) by receiving feedback and comments (Scanlon et al. 2011).

The learning units are examples that can be adapted to other contexts and foresee the integration of different school subjects during the implementation. For instance, the orientation phase can be implemented in geography and earth sciences, but also in history or literature, and other phases of the inquiry cycle can be carried out in other school subjects (e.g. science, botany, chemistry, etc.). Indeed, landscape studies are inherently inclusive, integrating different aspects that enrich the knowledge of the local territory and embody a holistic view. Therefore, a good coordination between different subjects is expected in order to perform the whole learning process, especially for gathering together the results from different investigations and summarizing the results from different perspectives.

New technologies in Daylighting Rivers

Daylighting Rivers promotes the use of new technologies for learning as well as for the promotion of the territory to the wider public. Platforms and apps that have been developed for mobile devices such as smartphones and tablet computers become the stage for innovative projects, using *Geographic Information Systems* (GIS) to create thematic maps and *Location Based Games* (LBG) to summarize results in an Augmented Reality environment (Figure 2) (Ugolini et al. 2016). These technologies allow students to gain technical skills and to develop spatial thinking abilities (visualization, orientation, and relations). Indeed, maps show georeferenced information in different ways, while LBG and gamification allow developing an informal language to transmit and exchange georeferenced information with others. In the laboratory of informatics, students can access such software tools and develop skills with the support of teachers and experts.
In addition, the development of location-based games implies the use of story telling. The acquired knowledge and in conclusions expressed in rigorous scientific language are conveyed through gamification and informal language in which fantasy and creativity replace the rigor of scientific reports. Gaming requires establishing a logical sequence of actions, following the dynamics of a storyboard which is rich in characters, quizzes and scoring to produce educational fun. Other skills are stimulated as well: communication, creative thinking, drawing, and logical thought – alongside technological and informatic skills.

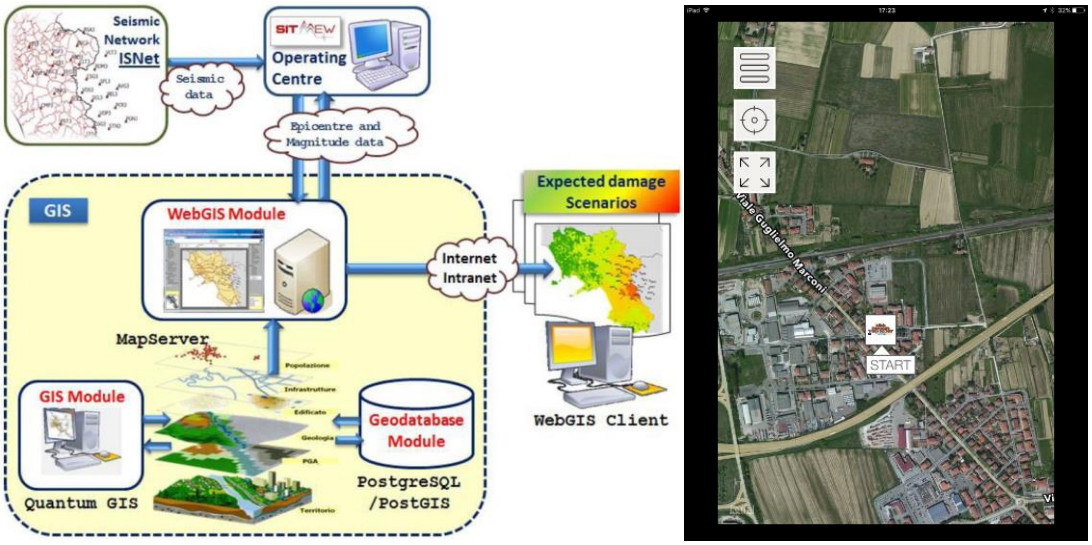

Figure 2. Left: example of a Geographical Information System (GIS) logical architecture (from Pollino et al. 2012). Right: game icon in a Location Based Game (LBG) playable on smartphones and tablets.

Discussion and conclusions

Daylighting Rivers has been successfully implemented and assessed (Ozdem and Cavas, 2020) in four Mediterranean countries, involving about 200 students in secondary school pilot projects. Teachers and students were empowered to focus on the local territory, investigating aspects connected to the history of the place, the environmental characteristics of the river and the water landscapes, and the evolution of urbanization with its impacts on the water quality and river management. Students could perform activities to understand the environmental threats, but also to think about possible solutions. Twenty learning units developed within the project can be downloaded from the project website www.daylightingrivers.com. Although these learning units focus on specific rivers, they can be used as examples that can be replicated and adapted to different contexts.
Assessment tools can be useful to test the effectiveness of the learning experience in terms of attitude, skills, and interest – and tools such as questionnaires are also available from the project website at: https://www.daylightingrivers.com/implementation/.
At the same time, the project has also brought to light problems and limitations, mainly in the use of technologies such as GIS. This was likely due to multiple factors, including the time requirements, the need for facilities such as an informatics laboratory, organizational and logistic limitations, and inadequate numbers of teachers with the required competence (even though training was provided within the project) and who can share the commitment and support for students, especially when the school curriculum does not include such technologies.
On the other hand, while location-based games may represent a great challenge in formal education and are likely to be considered of secondary importance, their development within the class is easier to handle as students are more familiar with virtual games. In some cases, it happens that skilled students learn digital tools and software and train and support their peers in the development of the game. The experience has demonstrated that the whole learning process enhances the collaboration and the organizational skills within the group of students, since they have the commitment to fulfil their own tasks for the benefit of the whole group and the realization of the game.
Therefore, we can conclude that the Daylighting Rivers approach and materials can be useful to:

- enhance transversal learning through the implementation of investigations in science and other school subjects like chemistry, math, economy, informatics, history and foreign language;
- impart hard skills in the use of scientific tools (e.g. worksheets, software and apps), and soft skills like synthesis and communication (using rigorous scientific language as well as storytelling);

- give students the possibility to use innovative software for georeferenced infomation (i.e. thematic mapping software) that can provide interest and skills useful for their future careers; and
- foster civic ecology and awareness among teachers, students and outside experts about environmental issues, and encourage creative thinking about solutions – as active promoters of responsible citizenship.

Acknowledgements
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RIVER SARNO: A SICK GOD

D'Ambrosio E., Gambino M.T., Marrazzo L.

Liceo Scientifico "N. Sensale", Nocera Inferiore (SA), Italy, elvira.damb@gmail.com, teresagambino65@gmail.com, linaengedhal@gmail.com

Abstract

Erasmus + Project Daylighting aims to investigate the problems connected to culverts built in some parts of rivers in Europe. In our school 48 students have been involved in activities which have investigated the river Sarno, one of the most polluted in Europe.

This river or its tributaries run through 39 towns, including our city, Nocera Inferiore, where the incidence of tumours is one of the highest in Italy, particularly in the 19-45 age group. These diseases are due to the pollutants discharged into the water courses in our area.

The teachers involved in the project designed and implemented the following learning modules: Influence of the structure and structure of the soil; The symbiosis between the Sarno river and its people; Ancient artifacts of the Sarno river; Eutrophication and integration of the river into the urban space. The Learning Units made use of IBL methodology, which enabled students to actively learn about the environmental problems connected to the construction of culverts and to pollution. They carried out various activities in class and along the river Sarno: they made hypotheses, collected data on two field trips, analysed them in order to test their hypotheses, discussed the results of their investigation.

In May 2019 the students took part in the "Fiume Sarno Rotary" conference held at the Real Polverificio Borbonico in Scafati and obtained a certificate of merit. The examining committee appreciated their activities and findings which highlighted that the discharge of sewer and pollutants into the Sarno have made it "a sick God" and heavily contributed to health risks.

Keywords: Sarno River, IBL methodology, culverts, pollution, learning modules

Introduction

"Sensale" high school is located in an area through which the Alveo Comune Nocerino, a tributary of the river Sarno, flows. The area, called *Campania Felix* by the Romans for its fertility and abundance of water, has now become extremely polluted because of human activity. The river, which used to watch over the ancient people living in the area and which was worshipped as a God (Fig. 1), has become one of the most contaminated in Europe.

Figure 1. Helvius fountain in S. Egidio del Monte Albino portraying the river Sarno as a god.

Changes to the place go back to the eighteenth century, when a complex network of mills, tanks, streams, drainage ditches and dams was built to exploit the river hydraulic force. These constructions modified the hydrographic landscape of the Sarno valley which underwent even more significant modifications during the great urban and industrial transformation of the 1970s (Fig. 2). This transformation caused the removal of the last marks of a sustainable and environmentally friendly production system as it implied a higher demand for food due to the growing population and therefore, an increased need for farming land. Industrial farming involved an extensive use of fertilizers to produce more crops which led to an escalation in poisoning waste being dumped into the river which highly contributed to its pollution. As a result, there was an acceleration in the eutrophication process. In fact, over the decades the amount of oxygen in the water has become less and less and this has caused the death of fish and mollusks. Urban domestic and factory waste discharged into the river Sarno and its tributaries have also brought about a high rise in the incidence of cancer, particularly among people aged 19-45.

Figure 2. Storm retention system near Montoro (SA).

Another dramatic change occurred when parts of the river were covered by culverts.
Culverting started as a way to reduce the appalling smell coming from those parts of water courses which neglect had transformed into open sewers. Afterwards, it became a way to increase land for building purposes in urban centres which were getting larger and larger. Unfortunately, culverts do not have the same flood capacity as an open river therefore, river areas are frequently afflicted by flooding which damages roads and badly affects production activities.
Erasmus + project **Daylighting Rivers**, which started in 2018, was a great opportunity for our school to raise the students' awareness about environmental issues in general and culverting in particular, whose negative consequences can be seen in our town every time it rains heavily.
The coordinator of the project was WREF - Water Right and Energy Foundation (Italia), the partners were CEBAS-CSIC (Spain) IBIMET-CNR - Istituto di Bioeconomia - CNR (Italy), ICASE (UK), IES 'Miguel Espinosa' (Spain), Liceo Sensale (Italy), PRISMA (Greece), Rafina Lyceum (Greece).

Methodology

The project involved 48 students and 7 teachers from Liceo Sensale and implied the designing and implementation of the following Learning Units:

- Influence of soil texture and structure
- The symbiosis between the river Sarno and its people
- Ancient artifacts of the Sarno river
- Eutrophication

First the students were given a questionnaire to fill in for the purpose of gathering information about their knowledge of rivers and environmental issues as well as about their interest in the topic. Next the implementation of the learning modules started and was achieved over a period of about 5 months.
The activities were carried out by employing **IBL** (Inquiry based learning) methodology. This learning approach has been recognized as one of the most effective in science teaching since it encourages students to become responsible for their own learning process. In fact, they are required to make hypotheses and to verify them through investigation. To this end they perform engaging and motivating activities which allow them to acquire their knowledge by doing.
The learning modules were implemented by following the five phases of Pedaste model: Orientation, Conceptualization, Investigation, Conclusion, Discussion.
The students did the tasks concerning the orientation and conceptualization phases in their classrooms.
Videos, photos and maps were used to introduce the topic and provide stimuli which could help them formulate hypotheses.
After that two field trips to the Sarno area were organized to let them collect data (Fig. 3) for the investigation phase so that their hypotheses and previous knowledge could be verified.

Figure 3. The students are collecting soil and water samples.

The students worked in groups. They went to sampling points which had been selected earlier and took water and soil samples; then they carried out chemical analyses and took measurements of the environmental parameters in order to investigate the pollution and degradation of the area. The outings also allowed them to study the historical aspects of the place. To this purpose they walked around and took photos of water mills and other interesting buildings situated there (Fig. 4 and 5). The photos were immediately geolocated.

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Figure 4. Watermill, Rio Palazzo; Figure 5. Watermill, Fiano

Then a visit to the Archeological Museum of Sarno Valley was organized (Fig. 6). There the students saw artifacts

and objects concerning people's life by the river over the centuries.

Figure 6. Museum of the Sarno valley.

On one of those trips they had the opportunity to interview uncle Peppe, an old man whose farm is crossed by the Rio Santa Marina, an enchanting, unpolluted small stream near the source of the river Sarno. In that place it is still possible to have a suggestive glimpse of the complex and diversified reality the local ancient populations could enjoy every day.

Figure 7. Foce, by the river source.

As a custodian of the environment he takes care of the area and shows people around in order to teach them how important it is to respect and preserve its charming beauty for future generations.
The students found the meeting with this person extremely inspiring as they had a chance to learn about the river from someone who cared about it. They also met and spoke to other people with a keen interest in the health of the river Sarno and gathered further information about its present degraded condition (Fig. 8).

Figure 8. Maintenance work on the aqueduct conveying the water of one of the Sarno sources.

The activities concerning the investigation phase were continued at school where the students worked in the science lab. There the concentration of nitrites and phosphates as well as the concentration of dissolved oxygen were measured in various experimental situations. The sampled water was used to create a model which enabled them to analyze and study the causes of eutrophication. After that the two last phases were performed. First discussion sessions were held in groups then class discussions were set up in order to draw and share conclusions. In the end a PPT was created by the students in order to summarize the results of their work.
https://drive.google.com/drive/folders/113bNGvAr2u1rVOt0IEd63omO25qnSHiW?usp=sharing

Various dissemination events were arranged, such as the annual conference of **The Rotary club** on rivers. During this event the students presented Daylighting Rivers project, explained about IBL methodology and illustrated what they had learned at the end of the various learning modules. They also offered suggestions for feasible actions to be taken to help save the river Sarno. The pupils' presentation and work were really appreciated by the people attending the conference. In fact, some journalists interviewed them and the examining committee gave them a certificate of merit.

Figure 9. Bird's eye view of an area of Nocera Inferiore where the river has been culverted.

Finally, an **app** was partially developed on **ARIS** platform. It works as a google map with two routes on it, one marked by letter H the other marked by numbers. Letter H refers to places of historical interest, while the numbers indicate the route along which the students performed the investigation activities.
When someone clicks on the start button they are asked which tour they would like to go on. If they want to learn about how human activities have affected the river Sarno they are told to follow the numbers. By clicking on them, pictures come up showing students while they are taking measurements or collecting water and soil samples in order to determine their pollution levels.
If people are interested in the historical tour instead, they are first sent to the Museum of the River Sarno valley site. After that they are asked to follow letter H on the map. By clicking on the icons, pictures of historical buildings, such as water mills, come up. You can see a draft of the app at the following link
https://1drv.ms/v/s!ApSgj3JozHkDsycUYn18eHnct6yF?e=96vNH8

Conclusions

Daylighting project gave our school the chance to promote interest in scientific subjects which young people perceive as distant from their daily life and experience. Moreover, it drew their attention to environmental issues which greatly concern our society since our life is strictly dependent on the health of our land and rivers. In fact, the outcome of the final questionnaire showed that their knowledge about the problems concerning rivers and the management of water resources had increased.
IBL methodology proved an effective tool to promote the students' active involvement in their learning process and helped them acquire a better understanding of the topic dealt with. This engaging learning approach allowed them to reinforce their creative and critical thinking skills as well as their ability to collaborate, work in team and make decisions.
Going on field trips gave them the opportunity to actually see and explore through their senses. They expanded on their learning in a more captivating way compared to their usual classroom work and were able to learn from hands-on experience. They actively took part in multiplier events. They prepared the materials to make presentations, expressed opinions, made suggestions about possible actions experts could take in order to decrease the current degradation which characterizes our rivers and their surrounding areas.
In conclusion, taking part in Daylighting Rivers project equipped the students with a more extensive knowledge of their surroundings and made them aware of the serious risks pollutants and neglect pose to the environment. They also realized how crucial it is to be responsible and committed citizens and to play a constructive role in helping develop a different attitude to the global challenges of our modern world. As educators we fervently hope that they will soon follow in the steps of those past students whose interest in environmental issues was sparked by similar projects and who have become eager green activists willing to fight for change every day.

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DAYLIGHTING RIVERS AT THE 1ST GENERAL LYCEUM OF RAFINA

Lazaris A.

1st General Lyceum of Rafina, Rafina, Greece

Abstract

Our program was a pilot project and its goal was to demonstrate whether the students would be able to approach interdisciplinary subjects concerning rivers and their ecology, and if they could match all this knowledge with the courses of the School Curriculum.

In order to attain the project goals, the students and teachers as well as specialised scientists had to succeed in working closely together on subjects like the study of the water catchment area of the river, land use, ecological river management, changes over time in water management, water quality, flood danger and its avoidance and many more. The project was quite demanding. Yet in spite of all the objective difficulties, it ran more or less successfully.

Keywords: biodiversity, science, hand-on activities, observations

Daylighting Rivers in Rafina

The Great Stream of Rafina is a river that crosses the coastal town of Rafina, Greece and is the only natural reserve in the area. It extends from the southern slope of the mountain of Penteli and the northeastern slope of Ymittos, crossing the plain of Spata and flowing into the sea in Rafina (Fig.1). It is an important wetland of Eastern Attica and one of the few streams that retains water all year round. Its importance for birdlife is evidenced by the fact that more than 100 species of birds have been recorded there.

Figure 1. The Great Stream of Rafina at the mouth, flowing into the sea.

Recently the authorities have pressed to apply what they call an anti-flood method and what we call a disaster. A full 15 kilometres of the river, including parts that are the most rich in beauty, are planned to be deprived of their

natural vegetation. More than 3000 trees, some of these centuries old, will be cut, never to grow again, since the entirety of the banks and the riverbed will be covered in concrete and gabions (metal boxes containing rocks), turning what now is a diverse ecosystem into an open water pipe with no eco-value.
In trying to better understand the Great Stream and the implications of these disruptions, our research faced great challenges as it was proven, as expected, that the river ecosystem is quite complex.
It is a dynamic ecosystem, constantly changing throughout the year.
It is an ecosystem that had each year an important portion of it destroyed under the bulldozers that are supposed to “clean” it from the fluvial sediment it transports.

Figure 2. Human transformations of the river.

The ambitious goals of our project were:
a) To study and highlight the Great Stream of Rafina ecosystem that faces the immediate danger to be transformed into a canalised river.
b) To address the key question that focuses on whether a canalised or a natural flow river performs its hydraulic function more successfully. When does a river protect us better from a possible flood; when in natural condition or converted into a semi-enclosed concrete canal?

It has been established that a crucial factor was the interest of the students who longed for a different learning approach, both cross- thematic and multidisciplinary.
It became possible through working with a small group of students, that every time included roughly twelve to fifteen of them, to fulfill tasks that even now would appear almost impossible for us.
The project activities started in October 2018 as a pilot, and kept going until May 2019.
The official application of Learning Units started in February 2019, when most of the students in the group were still in the first Lyceum grade, even if there were also a few in the second and third school grades.
Stamatis Zoggaris, a researcher in the Hellenic Centre for Marine Research, stood by with advice and expert help at all times, wholeheartedly supporting this major and demanding experiment.

All this, along with the tragic circumstances of the 23 July 2018 great wildfire in Mati and Rafina that radically altered the whole region. One hundred and two victims, thousands of dwellings burnt to the ground, one thousand two hundred hectares of burnt land and countless animals dead.
As if that were not enough, the Covid-19 pandemic was added towards the end of the project.
The implemented quarantine and the interruption of lessons prevented the students from creating a Location-based game as was their initial planning.
The game in which the problem of the river canalisation would be presented along with the student proposal for an alternative solution, was considerably scaled back as a result of the March to May quarantine obstacle, and also the new quarantine in November 2020 when schools were shut – and in fact still remain closed.

On the contrary, the students accompanied by researchers and scientists struggled to reveal and feel what the river had to say them.
“To study, to learn, to love...” is the triptych on which we worked.
We planned the investigation of the diversity of the river.
We focused mainly on Eels and Fishes as they are very good markers of the ecological situation of the ecosystem.
We also investigated Plants, Insects, Birds, Reptiles and Frogs.

Figure 3. Students examining evidence along the bank of the stream.

As mentioned before, the river is an important wetland of Eastern Attica and one of the few streams that retain water all year round. Its importance for birdlife is evidenced by the fact that more than 100 species of birds have been recorded. Hundreds of tree species grow on its banks; among them are the age-old aquatic plants such as plane trees (Platanus) and willows (Salix). Also, we can find common reeds (Phragmites australis), common bulrush (Typha latifolia) and other plants and flowers.

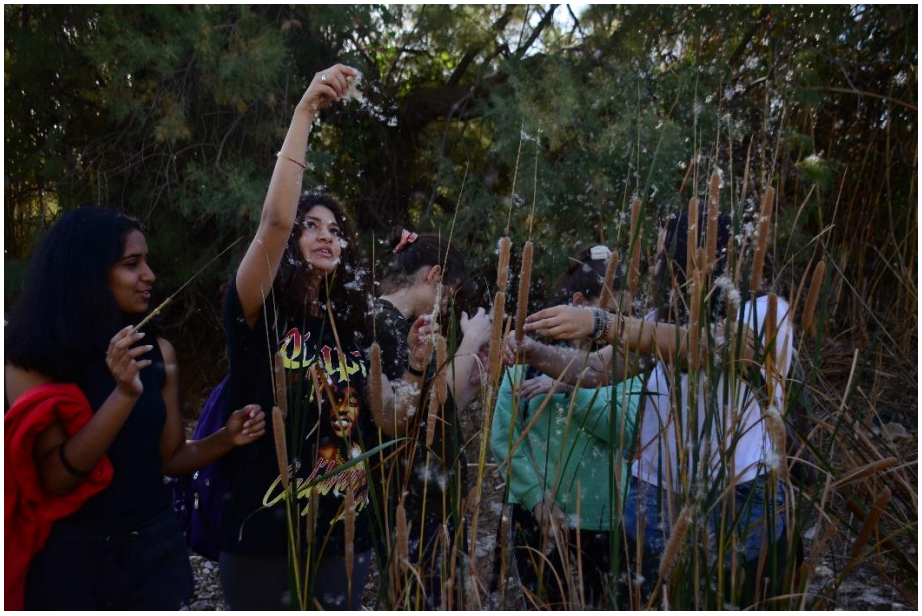

Figure 4. Documenting aquatic life among the bulrushes.

Wetlands are wonderful places, complex and unexplored.
Human vanity has been scarcely able to study and decipher them.
Wetlands form a palimpsest, a partially obscured document whose underlying layers reveal a record that has been kept of the evolutionary path – both of the river itself, and of the organisms living in and close to it.

Figure 5. Scanning for life in the shallow water at the stream's edge.

This rich ecosystem of the stream works beneficially for the whole of Eastern Attica (Fig. 6) and especially for our city. Its natural vegetation filters the pollutants that illegally end up in the stream from the surrounding businesses before they reach the beaches of the area. It largely filters the air pollutants from the port and the airport, regulates the climate and especially the temperature of the area, saves our city from the catastrophic floods that affect areas with muddy or covered streams, operates educationally and is a refuge for the conservation of biodiversity.

Figure 6. Rafina Stream in the inner land.

Despite what the Great Stream of Rafina offers us, the municipality and the periphery have decided and tried to cement it and turn it completely into an open rainwater pipe, ostensibly for flood reasons. The real reason, however, is the plans to expand the port of Rafina, and also a rumoured plan concerning the expansion of the Attica suburban railway. Although many actions have been taken to prevent the implementation of these plans, we have not seen a great response from the community and especially the municipality.

However, what we must understand is that not only the ecosystem of the stream is endangered but also ourselves. We focus on profit and forget the value of Mother Earth that has become a living dead. One more reason to protect this huge asset is climate change and the planet's screams for help. As long as we continue to destroy and neglect the environment, unfortunately, we will not be able to see any recovery of the situation.

The plan of the Government for the River will erase this natural landmark from the map, only to pave the road for the alleged economic growth that extensive building will bring to the area. Practically, it will also affect the microclimate, since the average temperatures will rise. Removal of trees will make the river's self-cleaning impossible, rendering the Attica coast prone to the critical danger of rising pollution. Climate change always settles step by step. Cement comes at a cost.

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AN EXPERIENCE OF INQUIRY BASED LEARNING ON SPAIN: EMBEDDING NEW LEARNING APPROACHES IN A HIGHLY REGULATED EDUCATION SYSTEM

García Martínez M.L.[1], Germán Escudero M.[1], López Pérez E.[1], Martínez Gea J.A.[1], Meseguer Santamaría M.C.[1], Palomares Carrascosa A.[1], Parras M.P.[1], Vidal Martínez M.C.[1], Barberá G.G.[2]

[1]IES Miguel Espinosa, Murcia, Spain, 30011338@murciaeduca.es
[2]Department of Soil and Water Conservation, CSIC-CEBAS, Campus Universitario, Espinardo, Murcia, Spain, gbarbera@cebas.csic.esmail

Abstract
Inquiry based learning (IBL) raises expectations on enhancing learning and motivation of pupils at schools as well as increasing science-oriented careers. Here, it is reported the experience of one secondary school (IES Miguel Espinosa) in Murcia (Spain) carried out during the development of Daylighting Rivers project. The orientation of the project was aimed at the study oft river courses in urban and suburban environment with an emphasis on intermittent and ephemeral water courses which characterize the semiarid region where the school is located. The implementation of learning units and fieldwork was hampered by existing school organization and regulations, which are framed by regional and national education structure and norms. It was difficult to embed learning units in the normal flow of contents pupils received, as covering the law- regulated curriculum contents is a priority. In this context, the activity may be perceived as an extra burden for both teachers and pupils, hampering the success and the intended objectives. In this particular case, fieldwork was intrinsic to the learning process and confronted additional problems as curricular activities out of the school are strongly constrained by safety norms and are difficult to be placed in calendar and time schedules. However, the experience was highly valued by pupils, especially concerning outdoor experiences. The adaptation of the experience to the new “Research-oriented Upper Secondary Education” model implemented on the region is discussed.

Keywords: inquiry based learning, temporal rivers, curriculum development, education regulation, outdoor education.

Introduction
In the framework of the project Daylighting Rivers the secondary school *Miguel Espinosa* of Murcia (Spain) implemented an experience of inquiry-based learning (IBL). The focus were rivers and other water courses (natural and artificial) in urban and suburban areas. In this paper we describe the experience especially in terms of its implementation embedded in the standard functioning mode of the learning at the secondary school and lessons learned and its possible application to the new curricular specialization introduced at the school known as “Research High School”.

In the first section of the paper they are described the main aspects of the proposal and the field sites were the IBL was implemented. In the second part they are reviewed the operational problems this kind of approach do present in the standard curricular functioning. In the third part the main aspects of the “Research High School” are introduced and lessons learned from the experience are discussed in order to optimize this new curricular especialization.

Daylighting Rivers in Murcia metropolitan area
Daylighting rivers concept is inspired in removing cover that hide many urban rivers (or urban reaches of rivers) in the world. In general, the concept is related to rewilding urban and suburban rivers which have been covered, channeled, polluted and lost their vegetation and other elements of biodiversity.

The project was to adapt the objects of the project to the characteristics of the region and the present day reality of the water courses:

(i) Murcia area is one of the driest of Europe, the town receiving 280 mm of precipitation per year. Permanent water courses are a rarity. Indeed, the whole region is dominated by the presence of only one 'real' river, the Segura river. Most of the basin of this river is receives less than 350 mm of precipitation per year. Its few permanent tributaries have very low flows. The draining network is dominated by intermittent water courses (flowing from one to several months per year, drying in summer and longer periods in dry years) and ephemeral water courses (flowing after some threshold of rain amount).

(ii) Rains can be very intense, for instance, in September 2019, close by Murcia town the amount of rain reached 500 mm in 48 h, that is to say nearly twice the year average. Therefore, water courses have been rarely covered, although many times simply have been occupied by the urban development.

(iii) The Segura river, crossing the Murcia town, was heavily polluted with the degradation peak in 1980s. Since then a comprehensive wastewater treatment plan was implemented and nowadays its water quality is good enough to be inhabited all along the course by otters, including the urban reaches.

(iv) Floodplain of the Segura river surrounding Murcia town is irrigated by a large scheme of channels since IXth century. These channels were very much naturalized in the past but most of this richness is now lost.

The main objective was the student getting knowledge of this reality through the selection of field site for the application of learning units and complementary activities. Selected sites were three:

(i) An ephemeral water course in the hills north of the main town. The water course basin is the main university campus. The area is a good example of a basin in a suburban area covered by a large amount of impervious surfaces which dramatically increase runoff downstream, also some sections of the water are covered. The water course has no direct connection to the general draining network and the outlet of the water course us through the streets of the town downstream the campus. The connection between the campus and the town is a place where wastes are dumped. The site is excellent let to discuss most of the problems affecting to urban water courses.

(ii) An intermittent river south of the town. It is surrounded on mean height mountains but very abrupt with a landscape prone to erosive processes. Although is very close to the main town it looks like very wild. The area let to handle concepts of water seasonality, rainfall infiltration, differences in vegetation between south and north slopes, erosion/sedimentation, water salinity. Upstream the basin citric crops percolate nitrate to the stream while the main river receives phosphate filtration from intensive pork farm. These effects are evident In water quality.

(iii) Between the main town and the point (ii) one section of well conserved and naturalized irrigation and drainage channels on the traditional irrigated land, where the functioning of the system and its natural and historical values can be observed.

The learning units were implemented basically on the site (ii) as the presence of water for an important part of the year and the wilder setting gave more opportunities for field work. They were analyzed animal and vegetation diversity, including the creation of a field guide of plants. The basic parameters of the water and possible sources of pollutants was also studied using field probes for physical and chemical variables. It was emphasized the concepts as well as the introduction to the fundamentals of field sampling and field equipment.

The combination of learning units with the survey of the territory stratified by its main types of water courses should get the students familiar with their own environment. Above at all students valued the outdoor experience which most of them were not familiar to. The 'wilder' aspects: rough terrain, short climbing, etc, were very exciting for them.

Operating IBL on a standard learning environment

The most complicated part of this piloting phase was to combine the activities of IBL with the rigid and protocolized standard learning enviornment.

The pool of students participating in the piloting phase was about 30, but the were splitted on several groups. Time-schedule of high school is strict and hardly enough for fulling developing the curricular requirements of each level. Learning units should to be embedded in this 'flow', with the additional problems that students participating in the project were not allocated to one unique group.

The main specificity of this IBL is that it necessarily required fieldwork. So, it was necessary: (I) to find additional time within the high school time schedule to carry out field visits; (ii) require permits and parents authorizations for the extra activities out of the high school; (iii) to organize logistics for trips to the field sites hiring an adequate bus; (iii) manage a group close to 40 people to work in the field on different activities; (iv) do not exceed normal high-school schedule; (v) availability of teachers participating in the project, being necessary to alter their own teaching schedules.

This organizational problems precludes the routine application of IBL approach on the standard learning environment. The activities in High School activities may be alleviated in terms of organization, but field work is difficult to be reorganized as security norms are strict.

IBL and Research High School

The organization of research high school curriculum in the Region of Murcia

The Basic Law of Education in Spain is subjected to chronic instability, and when governments change fro right to left or viceversa, law is changed once again. Anyway, the Basic Law(s) establish as an objective of the High School to develop the skills to understand the fundamentals of scientific research and methods as well as both the ability for autonomous work and team work. In the Region of Murcia, it was established the Research High School curriculum to promote these aspects (BORM, 2009). This research curriculum does not substitute the standard high school but complement it. The participation in the curriculum is both volunteer to students and centres.

The objective of the research high school curriculum is to promote scientific vocations, to favor scientific reasoning and to strenghten ties between teachers and students using scientific research. One high school qualified by the regional Education Ministry for research high school as a separate group for the research high school curriculum, maintaining the standard curriculum for the rest of the centre, so there are no only research high schools but the curriculum is a more or less experimental group in the qualified high schools. The qualified high school has to offer a subject named "Intiation to the research" which does not exist in the standard curriculum. The teachers ascribe voluntarily to the curriculum, and get specific formation and a minimal (1 h per week) reduction in teaching.

The core difference of the research curriculum from the standard curriculum is that basic methodology is the scientific research. This is understood as the ability to search and handle sources of information, and to plan, execute and present a topic of research produced using the scientific method. Along the course the student has to elaborate the project of research.

There is a fundamental distinction depending on the subject. Science and technology subject the essential is research work, use of ICT and lab practices. On humanities, social sciences and arts the orientation is to text analyses and writing essays, as well as research works, but in this case the character of a research work is not specified, but it is assumed to be research works based on documents.

The experience of Daylighting Rivers and the research curriculum in Murcia's high schools

In terms of teaching and learning, the objectives of Daylighting Rivers and the research curriculum are very similar. However, there are also some differences which matter.

Research curriculum is organized around specifically created groups, with dedicated teachers. This is a substantial difference to the situation of Daylighting Rivers where the IBL was overlaid to the standard forms of teaching. This hampered the smooth development of the IBL because: (i) it was an additional burden both for teachers and students to the already dense standard curriculum: (ii) organization of IBL did not match to the general teaching organization.

From this fact one question immediately arises. Is it possible the implementation of some IBL oriented topics embedded in a standard curriculum? From our experience it does not seem very advisable. Such approach that could be a good introduction of IBL without changing the whole curriculum structure can confront with the rigid organization of present-day schools, at least as it is known in Spain. Then, the alternative is changing the curriculum to a research-like form similar to Region of Murcia approach. But we have to remind that this is considered an experimental curriculum offered to a minority. In the Murcia's regulation it is one group with 20 a 30 students per centre. Even in a public education system this minority is probably to be wealthier, coming from better educated families and obtaining better marks than the average families.

In the region, the offer of the research curriculum is, therefore, more oriented to promote scientific vocation and scientific culture to already predisposed students but does not seem focused to change the system. Daylighting Rivers foundations is about to introduce IBL more as a norm than as an exception; with the organization of the standard curriculum it can be difficult.

Research curriculum in Murcia is structured around three pillars: (i) learning to search and process information; (ii) stress on the scientific methodology; (iii) a research work that the student elaborates along the whole academic year. It is precisely this last point which is, probably, more important and can not be introduced in the standard curriculum. Learning units as implemented in Daylighting Rivers are mini research works where all the class is involved. During the work students were organized in groups but these groups were more related with individual tasks than with the complete elaboration of a research work.

Taking into account all the possible problems and the experiences learned on Daylighting Rivers a mixed strategy can be devised in order to partially introduce the IBL embedded in a standard curriculum. Instead of implementing an IBL learning unit in a continuous way, the unit can be implemented along the *whole* academic year. This makes possible to find more 'spare time' in such a way that the learning unit does not impacted as an overburden over the standard curriculum. On the other hand, learning units can be 'redressed' based on the compulsory content of the curriculum. Instead of creating completely new learning units as it has been carried out in Daylighting Rivers, the IBL learning units can be created by aggregating contents of several related units of the standard curriculum so does not *add* but *complement* the compulsory contents. A longer development of the IBL learning unit also can let the students developing mini research projects linked to the IBL learning unit in a slower and more productive mode.

Research curriculum does emphasis in the search of information and the use of labs *but not* the field work. Searching information is easier than ever on the history of the humanity, although the excess of information frequently translates in absence of information. The labs at high schools are relatively limited and fieldwork, as we saw before is complicated, at least in the situation we know. So, the resources and organization of the school may be very limiting in the experimental part of IBL. Here there is clearly a worse situation for purely scientific IBLs than for IBLs related to humanities. One option is to limit experimental part of any scientific IBL to the labs but it simply ends any possibility of something like Daylighting Rivers. Here there are no simple solutions if we operate under the normative which exists nowadays. The most logical action is let the groups students to work themselves in the field, in carefully chosen safe places, but this is probably full of legal issues.

Conclusions

IBL approach as implemented in Daylighting Rivers in *Miguel Espinosa* high school was a good experience for students but resulted in problems to be smoothly implemented overlaid to standard curriculum. The research curriculum introduced in the region one decade ago promote objectives and methods similar to IBL but it is thought to be offered only for a little number of students. Introducing IBL in the standard curriculum needs a careful approach and probably a better integration between the IBL part and the standard part. It can be achieved better adapting the learning units to the compulsory content of the curriculum and extending the learning unit implementation along the course. Experimental work, especially fieldwork will be still a challenge.

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AN INVESTIGATION ON STUDENTS' PERCEIVED CHANGE IN ATTITUDES TOWARDS STEM AND CARREER DECISION SELF-EFFICACY IN DAYLIGHTING RIVERS

Ozdem-Yilmaz Y.[1, 2], Cavas B. [1, 3]

[1]*International Council of Associations for Science Education (ICASE) - UK*
[2] *Mugla Sıtkı Koçman University, Muğla, Turkey, yaseminozdem@mu.edu.tr*
[3] *Dokuz Eylul University, Izmir, Turkey, bulent.cavas@deu.edu.tr*

Abstract

Daylighting Rivers is a European Union-Erasmus Plus project that engages secondary school students in hands-on, interdisciplinary investigations of their local environment particularly the river ways with an emphasis on the ways in which urban growth and river management impact local ecosystems. The project team prepared educational modules, which are lesson sequences that require students to perform some open-ended tasks related to the river ways that flow through their city. In the project, after implementing educational modules, it is aimed at identifying the students' perception towards change in attitudes towards STEM and change in their career decision self-efficacy. Two questionnaires were circulated to secondary education students at the participating schools in 4 partner countries. One is regarding the perceived change in attitudes towards STEM subjects and the second questionnaire measured the perceived change in their career decision self-efficacy. The main findings of this study showed that the implementation of even one educational module with high school students has students to perceive slightly positive changes in their attitudes towards STEM subjects and slightly higher levels of career decision self-efficacy. Moreover, the results indicated that students who perceive a positive change in their attitudes towards STEM subjects as a result of educational modules, also perceived higher self-efficacy in career decision-making. The results were encouraging in terms of implementing more educational modules with more high school students. The outcomes of this study will provide unique experiences and feedbacks for stakeholders who are responsible for rivers and environmental challenges in teaching and learning process.

Keywords: Daylighting Rivers, Career Decision, Self-Efficacy, Attitudes

Introduction

This research was aimed at investigating the impact of Daylighting Rivers project on secondary students' knowledge about rivers and their ecosystems, their attitudes towards science, technology, engineering and mathematics (STEM) disciplines, and their career decision self-efficacy towards STEM subjects. Daylighting Rivers is a European Union-Erasmus Plus project that engages secondary school students in hands-on, interdisciplinary investigations of their local environment particularly the river ways with an emphasis on the ways in which urban growth and river management impact local ecosystems. The project team prepared educational modules, which are inquiry-based and technology-enhanced lesson sequences that require students to perform open-ended tasks related to the river ways that flow through their city.

In the following, the background to this research, its methodology and findings were presented, and they were discussed in terms of the objectives of the project.

Background

In today's knowledge-based economies, sustainable growth is in parallel with countries' capacity to innovate and create high-tech products. In this sense, Science, Technology, Engineering and Mathematics (STEM) fields, which have the potential to create opportunities for innovation, economic development and existence in the world of science and technology, and their education have been gained more importance than ever (Organisation for Economic Cooperation and Development [OECD], 2010). Improving science teaching and encouraging more young people into the sciences have already been a key objective of science education at all levels in Europe for

years. However, recently, many studies have shown a sharp decline in young people's interest for STEM fields. For example, the OECD indicates that over the last decade, in many European countries, although the number of young people enrolled in higher education is increasing, they do not choose studying STEM fields. Furthermore, reports in Europe argue that among the population in general, the acquisition of skills essential to live and work in the 'global knowledge economy', such as critical thinking and scientific reasoning that will enable citizens to make well informed choices, is alarmingly decreasing.

The research, investigating the declining interest among young people in studying science, found a firm connection between negative dispositions of young people towards science and the way science is taught in schools. The reality of classroom practice in science and mathematics subjects in most European countries causes students to perceive these disciplines as irrelevant to their life and hard to study. As a strategy to tackle this problem, and to increase young people's interest in and aspirations to careers in STEM disciplines, the European policy discourse and funding made the dissemination of active, participatory, integrative and interdisciplinary teaching approaches, specifically inquiry-based and problem-based teaching, a priority in science and mathematics classrooms. For example, the European Commission Report, known as Rocard Report (2007), recommended that inquiry-based approaches be brought in schools to encourage more students to follow a career path in STEM areas.

Inquiry-based approaches to learning and teaching science and mathematics involve students in the processes of these disciplines in the way mathematicians and scientists work in real. Inquiry is defined as "the intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments" (Linn, Davis, & Bell, 2004, p.4). Inquiry-based learning (IBL) has been proved to support students "engage with phenomena, develop inquiry skills and scientific reasoning, understand the meaning of doing and talking science, develop epistemological awareness of the nature of science and develop positive attitudes towards science" (Constantinou, Tsivitanidou, & Rybska, 2018, p. 9). Developing inquiry skills is part of the wider scientific literacy goal, which is crucial for understanding and decision-making in science-based societal issues in a world, which rely heavily on scientific and technological advances.

Daylighting Rivers project recognizes that science is, too often, seen as disconnected to students' out-of-school life and separate from all other subjects or disciplines in education. Thus, based on the research about STEM and IBL, the project aims to show that science is in all parts of people's lives and in our decision-making processes. It has been initiated on the need to involve young students in a dialogue and scientific investigation. Among the project objectives, the project targets students' generic skills such as logical thinking, problem solving and creative thinking. Moreover, we expect to engage students in effective collaborative knowledge and obtain inquiry learning skills, which can be useful to make school more attractive and for their future career. In mid-term, the project aims to increase the interest for and attitudes towards STEM in general through the involvement of students on familiar issues of their own town, and in long-term increase the number of students in scientific and technological careers. This research is the investigation of to what extent the project achieved its objectives.

The research questions guiding this study are; After engagement in Daylighting Rivers educational modules,

1. Is there a perceived change in students' attitudes towards STEM disciplines?
2. Is there a perceived change in students' career decision self-efficacy towards STEM subjects?
3. Is there a relationship between change in students' attitudes towards STEM disciplines and change in students' career decision self-efficacy towards STEM subjects?

Methodology

The cross-sectional survey design methodology was used in this research. The study initially was planned as pre-test post-test experimental design, yet due to the inconveniences in the implementation of the pre-tests prior to the study, the research methodology was adjusted to the survey research. The measures were also adapted to this methodology. For this reason, any changes reported in this research are the perceived changes by the participants after participating to the project. The online surveys were applied after the implementation of technology and IBL-based educational modules in all three schools in partner countries.

Educational modules

The educational modules developed in Daylighting Rivers project are based on IBL model and involve the use of technologies that might be useful in STEM disciplines and so students' future career. In line with IBL model, the modules developed in the project foster scientific investigation skills (identification of hypothesis, methodology and argumentation around results) as well as informatics and technological skills (e.g. Geographic Information Systems and Location Based Games). The content of the modules is in strong connection to the students' environment.

The modules are structured in the following order:

1. The first part engages students by raising their curiosity and eliciting prior knowledge on the topic,
2. The second part indicates investigation activities that concern different aspects (e.g. data collection and analysis about urban sprawl, tracking the covered rivers, water sampling, modelling on sediments dynamics or hydrological cycle etc.),
3. The third part is the explanation of the results and problem solutions.
4. The last part is the elaboration phase, in which they will be asked to design a project for 'daylighting rivers' and/or a location based game along the covered stream to raise also the awareness of the general public.

This structure has several advantages. Firstly, it is applied to contexts real and familiar to the students with field visits, data collection, and mapping. Secondly, it enhances transversal learning by scientific investigations that involve different STEM subjects and scientific skills with the use of protocols, worksheets, and landscape models. Thirdly, it enhances the informatics skills using open source software and platforms (e.g. Q-GIS as Geographic Information System, Arisgames or Enigmapp for Location Based Games). Therefore, the modules contribute to the development of skills and new knowledge that can be useful for students' future career.

Participants

The population of the study is all students who participated in the lessons by Daylighting Rivers educational modules. In this study, we did not choose a sample because the whole population was in reach. If the population of the study could be extended after the dissemination of educational modules, the population of this study might serve as a sample for further studies. The population of the study were the secondary students at schools in 3 partner countries, namely, Italy, Spain, and Greece. The students were secondary level students. In total, the participants were 11 students from Athens, Greece, 23 students from Murcia, Spain, and 33 students from Salerno, Italy.

Data collection

Data were collected by two questionnaires described below. The questionnaires were transferred to Google Drive cloud in the form of a survey. After the implementation of an educational module, the students were shared the link to the questionnaire by their teachers and they individually signed into the document and responded to the questionnaires. The data gathered were deposited in Google Drive. The questionnaires used in the research were as the following:

Change in Attitudes towards STEM Questionnaire. Originally named as "Student Attitude toward STEM Questionnaire", the instrument was developed by Mahoney (2010). Due to the design of this study, we adapted the questionnaire to ask for students' own perceptions of the change they experienced regarding the items in the original questionnaire. That is, the questionnaire as is used in this study provide information of the students' perceived change in their attitudes toward STEM. The questionnaire, as in the original version, has four parts, namely awareness or initial interest, perceived ability, value, and commitment or long-term interest. In the original questionnaire, there are 24 items, but each item should be evaluated per STEM discipline, so this makes 96 items to be responded. However, in this study, 12 items were selected (3 from each part) that would be adequate to evaluate the change in students' attitudes toward STEM to inform the Daylighting Rivers project. Each item was evaluated per STEM discipline as in the original questionnaire. The internal reliability, which was estimated though the use of Cronbach's alpha internal consistency coefficient in the original study was between .95-.97 overall for each STEM discipline. In this study, the internal reliability values were between .89-.94, indicating high reliability.

Change in Career Decision Self-Efficacy Questionnaire. The original Career Decision Self-efficacy questionnaire was developed by Presti et al (2012). The questionnaire includes 25 items assessed by Likert type scale. There are 5 categories composing the questionnaire, namely self-appraisal, occupational information, goal selection,

planning, and problem solving. Due to the design of this study, we adapted the questionnaire to ask for students' own perceptions of the change they experienced regarding the items in the original questionnaire as in the other instrument. The reliability coefficient which was estimated though the use of Cronbach's alpha was .95 in this study.

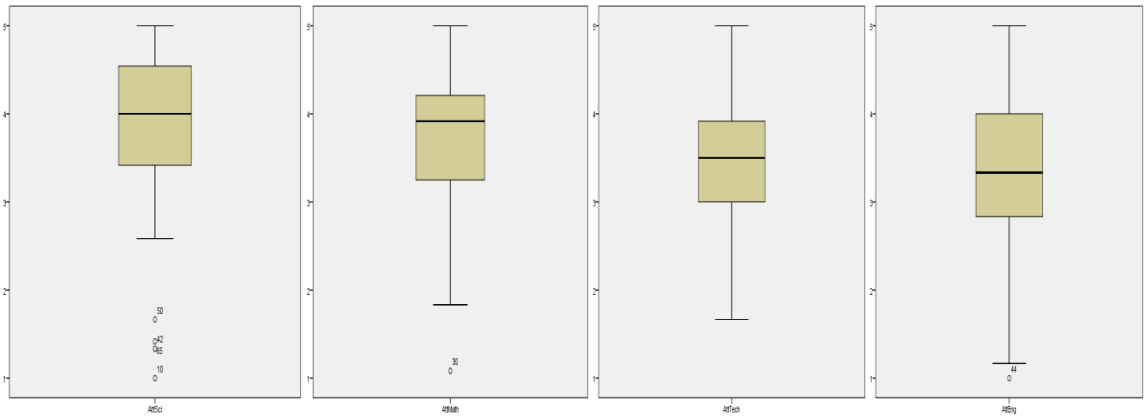
Data analysis

Data were analysed in three steps: (1) The descriptive analysis of change in attitudes towards STEM and comparative analysis among high schools, (2) the descriptive analysis of change in career decision self-efficacy and comparative analysis among high schools, and 3) the correlation to investigate the relationship between change in attitudes towards STEM and change in career decision self-efficacy. The analyses were also examined with respect to each high school (HS).

Results and Discussion

Change in attitudes towards STEM

The analysis of the change in attitudes towards STEM for each STEM subject resulted with the mean values given in Graph 1.



Graph 1. Change in attitudes towards STEM values (attitudes towards science, towards math, towards technology, and towards engineering)

According to graph 1, the students' perceived change in attitude towards each STEM subject is slightly towards a little more positive than before (μ=3.89, sd=.89 for science; μ=3.72, sd=.77 for math; μ=3.45, sd=.73 for technology; and μ=3.29, sd=.88 for engineering). Overall, the change in attitudes towards STEM is also slightly towards a little more positive than before (μ=3.59, sd=.56). In other words, students developed slightly more positive attitudes towards STEM subjects. The result can be interpreted as the positive impact of the educational modules developed in Daylighting Rivers project in contributing to the development of students' positive attitudes in STEM subjects.

The comparison between high schools resulted with the values given in Table 1.

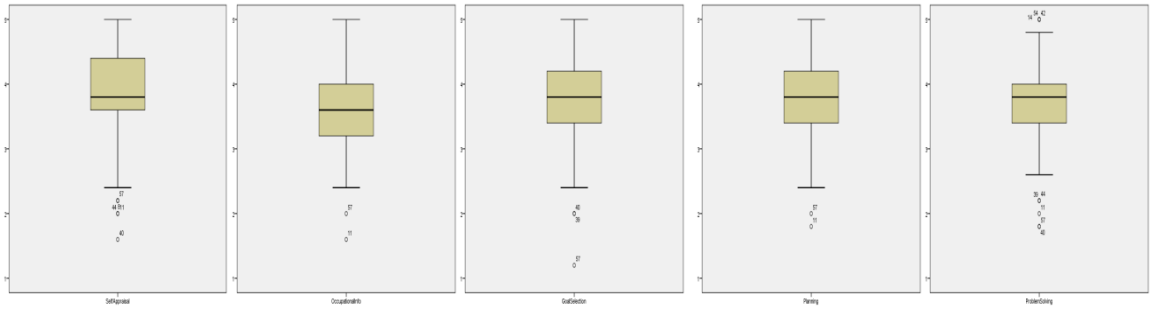
Table 1. The comparison between high schools in change in attitudes towards STEM

	HS	Mean	*SD*	*χ2*	*p*
AttSci	Liceo Scientifico "Sensale"	3.85	.63		
	1st General Lyceum of Rafina	4.02	1.44	4.15	.13
	IES Miguel Espinosa	3.89	.92		
AttMath	Liceo Scientifico "Sensale"	3.55	.84		
	1st General Lyceum of Rafina	3.65	.80	3.29	.19
	IES Miguel Espinosa	3.99	.58		
AttTech	Liceo Scientifico "Sensale"	3.23	.70		
	1st General Lyceum of Rafina	3.77	.73	6.37	**.04**
	IES Miguel Espinosa	3.62	.69		
AttEng	Liceo Scientifico "Sensale"	3.37	.78		
	1st General Lyceum of Rafina	3.56	.61	1.98	.37
	IES Miguel Espinosa	3.05	1.08		
Attitude	Liceo Scientifico "Sensale"	3.50	.59		
	1st General Lyceum of Rafina	3.75	.51	2.61	.27
	IES Miguel Espinosa	3.64	.54		

Because the normality assumption is not met due to the small sample sizes, a Kruskal-Wallis Test was performed to reveal the statistical significant difference in change in attitudes across three different high schools (Gp1, n = 33: Liceo Scientifico "Sensale", Gp2, n = 11: 1st General Lyceum of Rafina, Gp3, n = 23: IES Miguel Espinosa), $\chi 2$ (2, n = 67) = 2.61, p = .27. The high schools did not differ in their change in attitudes towards STEM. When change in attitudes towards each STEM subject was examined, there was a statistical significance in change in attitudes towards technology scores ($\chi 2$ (2, n = 67) = 6.37, p = .04), where the 1st General Lyceum of Rafina indicated a slightly more positive attitude towards technology with a recorded higher median score (Md=3.91).

Change in career decision self-efficacy

The analysis of the change in career decision self-efficacy and for each sub-dimension resulted with the mean values given in Graph 2.



Graph 1. Change in career decision self-efficacy values (self-appraisal, occupational information, goal selection, planning, problem solving)

According to graph 2, the students' perceived change in career decision self-efficacy is slightly towards a little more likely (μ=3.82, sd=.77 in self-appraisal; μ=3.58, sd=.66 in occupational information; μ=3.68, sd=.71 in goal selection; μ=3.73, sd=.66 in planning; and μ=3.71, sd=.72 in problem solving). Overall, the change in career decision self-efficacy is also slightly towards a little more likely than before (μ=3.70, sd=.65). In other words, students feel slightly more self-efficacy in making career decision in STEM disciplines. The result can be interpreted as the positive impact of the educational modules developed in Daylighting Rivers project in increasing students' self-efficacy in making decisions related to STEM careers.

The comparison between high schools resulted with the values given in Table 2.

Table 2. The comparison between high schools in change in career decision self-efficacy scores

	HS	Mean	*SD*	*χ2*	*p*
Self-Appraisal	Liceo Scientifico "Sensale"	3.63	.89		
	1st General Lyceum of Rafina	4.14	.46	3.00	.22
	IES Miguel Espinosa	3.91	.68		
Occupational Information	Liceo Scientifico "Sensale"	3.41	.75		
	1st General Lyceum of Rafina	3.82	.26	3.19	.20
	IES Miguel Espinosa	3.68	.63		
Goal Selection	Liceo Scientifico "Sensale"	3.53	.84		
	1st General Lyceum of Rafina	3.84	.46	1.09	.58
	IES Miguel Espinosa	3.79	.61		
Planning	Liceo Scientifico "Sensale"	3.54	.73		
	1st General Lyceum of Rafina	4.04	.44	4.30	.12
	IES Miguel Espinosa	3.82	.59		
Problem-Solving	Liceo Scientifico "Sensale"	3.50	.80		
	1st General Lyceum of Rafina	3.85	.41	4.74	.09
	IES Miguel Espinosa	3.92	.68		
Career Decision Self-efficacy	Liceo Scientifico "Sensale"	3.52	.76		
	1st General Lyceum of Rafina	3.94	.30	3.05	.22
	IES Miguel Espinosa	3.82	.57		

Because the normality assumption is not met due to the small sample sizes, a Kruskal-Wallis Test was performed to reveal the statistical significant difference in change in attitudes across three different high schools (Gp1, n = 29: Liceo Scientifico "Sensale", Gp2, n = 11: 1st General Lyceum of Rafina, Gp3, n = 23: IES Miguel Espinosa), $\chi 2$ (2, n = 63) = 3.05, p = .22. The high schools did not differ in their change in career decision self-efficacy. When change in each dimension of career decision self-efficacy was examined, there is no statistical significance between high schools in any dimension (p>.05).

The relationship between change in attitudes towards STEM and change in career decision self-efficacy

The relationship between change in attitudes towards STEM and change in career decision self-efficacy was investigated by Spearman's rank-order correlation (rho) due to the violation of normality assumption. The result was given in Table 3. There was a strong, positive correlation between the two variables, rho=.496, n=67, p<.001, with positive change in attitudes towards STEM associated with higher levels of change in career decision self-efficacy.

Table 3. The correlation between change in attitudes towards STEM and change in career decision self-efficacy scores

			Attitude	CareerDecSE
Spearman's rho	Attitude	Correlation Coefficient	1,000	,496**
		Sig. (2-tailed)	.	,000
		N	67	63

**. Correlation is significant at the 0.01 level (2-tailed).

Conclusions

In conclusion, the results showed that the implementation of even one educational module with high school students has students to perceive slightly positive changes in their attitudes towards STEM subjects and slightly higher levels of career decision self-efficacy. Moreover, the results indicated that students who perceive a positive change in their attitudes towards STEM subjects as a result of educational modules, also perceived higher self-efficacy in career decision-making. The results were encouraging in terms of implementing more educational modules with more high school students.

Acknowledgements

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AN EXPLORATION INTO STUDENTS' LEARNING NEEDS, INTERESTS AND ATTITUDES IN RELATION TO RIVER ECOLOGY, MANAGEMENT AND PLANNING

F. Papageorgiou, D. Mylonas

PRISMA, Centre for Development Studies, Athens, Greece
foulipapageorgiou@prismanet,gr,, d.mylonas@prismanet,gr

Abstract

This paper brings together the findings of a survey carried out in seven secondary schools located in Italy, Greece, Spain and Turkey, in the context of the Erasmus+ project Daylighting Rivers. The objective of the survey was to offer a "snapshot" of the knowledge, skills, interests and attitudes of students in such fields as urban river management, urban ecology and planning; and moreover explore their aptitude to become engaged in Inquiry-Based Learning (IBL) and their readiness to use mapping and games technology during the pilot course conducted in the context of the Daylighting Rivers project. In total 354 students responded to the survey, aged 14 to 17 years. The research findings helped the project team to adapt the IBL methodology to the needs of the students of the piloting schools and design the learning modules that were used in the pilot testing so that they would be relevant to the learners, helping them to develop further their multidisciplinary STEM knowledge and all-round environmental awareness. On the whole, the respondents showed relatively high levels of knowledge and interest in the environmental features of rivers, relatively high awareness and positive attitudes towards issues of environmental protection and possessed adequate skills as well as interest towards learning methods associated with IBL, while they possessed sufficient digital skills, although not in mapping technologies and game development. In certain cases substantial variations have been observed between schools, which need to be taken account of by the teachers, who can exploit the opportunities offered by the project to work with these students through IBL, stimulate their interests and enhance their knowledge, skills and positive environmental attitudes.

Keywords: IBL, STEM, river management, planning, environment

Introduction

This paper brings together the findings of a survey carried out in seven secondary schools located in Italy, Greece, Spain and Turkey, in the context of the Erasmus+ project Daylighting Rivers. The objective of the survey was to offer a "snapshot" of the knowledge, skills, interests and attitudes of students in such fields as urban river management, urban ecology and planning; and moreover explore their aptitude to become engaged in Inquiry-Based Learning (IBL) and their readiness to use mapping and games technology in the course of study. The participating schools are:

- Liceo Scientifico Sensale, located in Nocera Inferiore, Campania and Liceo Scientifico Copernico, located in Prato, Tuscany, in Italy, both scientific schools of upper secondary grade (ages 14-19 years).
- 1st Lyceum and 1st Gymnasium of Rafina, located in Attica, Greece, both typical higher and lower (mandatory) secondary schools respectively (ages 15-18 and 12-15 years).
- IES Miguel Espinosa, located in Murcia, Spain offering compulsory (4 grades) and non-compulsory (2 grades) secondary education for students aged 12-18, providing additional facilities and resources for physically and mentally disabled students.
- BILFEN Anatolian School and Science High School, located in Izmir, Turkey, representing two distinct types of secondary schools in the Turkish education system: the former offers bilingual studies and the latter addresses students of exceptional aptitude in the sciences.

The results of the survey were used to adapt the methodology of IBL to the needs of students and formulate the learning modules to be used in the piloting classes so that they are relevant and appropriate for implementation in the four pilot locations.

Methodology

The survey methodology was based on the administration of a self-assessment questionnaire. A specially designed questionnaire was administered in the seven participating schools. The questionnaire was designed to permit small adjustments accounting for the particularities of the different survey locations and the special characteristics of the river in focus in each location.
The questionnaire took around 15 minutes to complete and included four groups of questions:

1. Profile –seeking key information on the respondents' demographic characteristics i.e. gender, age; and the name of the school they attend.
2. Knowledge - seeking to identify the gap between the current level of the respondent's knowledge and the desired level of knowledge on different issues relating to the ecology of urban rivers, urban planning and river management.
3. Skills – assessing the current level of the respondent's capabilities to become involved in the delivery of the learning methodology adopted by the project, namely IBL; and in the utilised ICT tools, i.e. Geographic Information System (GIS) software, Location-Based Game platforms.
4. Interests, perceptions, attitudes - assessing the students' interest in the project themes, as well as mapping their perceptions and attitudes on the topics brought forward by the project.

4-point Likert scales were used to assess the respondents' knowledge, skills, interests and attitudes. To construct the questionnaire, the research team utilised partly the results of ROSE (Relevance Of Science Education - a cooperative research project that enlisted wide international participation, addressing how young learners relate to Science and Technology), appropriately and selectively adapted and further developed. The questionnaire was administered to full classes, following an introduction by a teacher, and accessed online. The students were either summoned in the ICT room of the schools, where they could use the school computers; or the teacher in charge sent students the link by email to fill the questionnaire in their own time.

Results of the survey

The sample

The following samples were achieved in the participating schools:
In Italy, Liceo Sensale & Liceo Copernico: 93 students
In Greece, 1st Gymnasium and General Lyceum of Rafina: 99 students
In Spain, IES Miguel Espinosa school: 36 students
In Turkey, BILFEN Anatolian School and Science High School: 126 students
In total 354 students responded to the survey.
The students' sample across the four countries was evenly divided to boys and girls, with slightly more boys than girls. The age of students varied between 14 and 17 years, with the mean age per country ranging from 15,5 in Italy to 14,5 in Spain.

Definition of terms

The project has been using a number of terms that are not necessarily familiar to students, such as blue and green infrastructure, urban planning, river basin management and river culverting. To assess to what extent the teachers should devote time to familiarize students with these terms, students were also invited to check their understanding of them. The majority of respondents across countries admitted very limited knowledge of what blue and green infrastructure or river basin management meant, and additionally, most Spanish students did not know what urban planning was.

Possessed Knowledge and interest to learn more

Regarding existing knowledge, the respondents' awareness of the rivers crossing their towns/cities or running near them was assessed. The level of awareness varied between the different locations of the survey. Thus, almost all the Italian students could name a river located nearby, in Murcia the level of awareness fell to 70%, in Rafina to 50% and in Izmir fell to 30%. A different picture was obtained in relation to students' knowledge of covered rivers in or near their town or city. When asked to name a covered river, the vast majority of respondents reported no knowledge of them, in all survey locations.

Further issues defining salient river's features or affecting the rivers and the areas surrounding them were offered for knowledge check, as shown in Fig. 1. The respondents overall reported higher knowledge on such issues as pollution and river ecology or river flooding. Lower knowledge level was reported on history of local rivers and the impact of climate change on them, while on other issues the level of knowledge appeared to differ substantially between different locations.

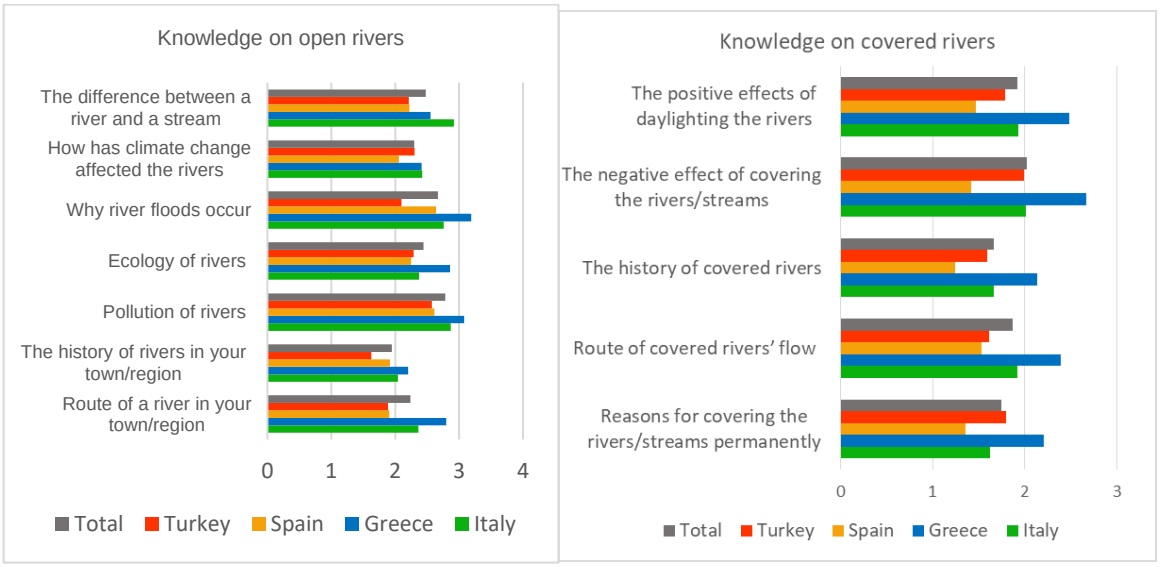

Figure 1. Level of self-assessed knowledge of issues relating to open and covered rivers

Regarding covered rivers, assessment of knowledge on such issues as reasons for covering, positive aspects of uncovering and the history of covered rivers confirmed a low to very low level of knowledge on the above aspects, as shown in Fig. 1. Some systematic trends emerged, pointing to variation of assessment across the different survey locations. For example, Greek students rated their knowledge higher than their colleagues, in other countries. The explanation for this may lie in the publicity surrounding the intention of the local authority of Rafina to cover part of the local river, leading to mobilization of local students and teachers.

Students' interest in learning more about river management and ecology was also explored and compared to their assessed knowledge levels, The respondents across countries showed interest mostly in learning about river pollution, climate change and problems related to rivers; mild interest in river flooding and reasons for covering rivers, and no particular interest in learning about the history of their local rivers, apparently being unaware of the strong connection between the historical evolution and the current state of rivers. Compared to the self-assessment of knowledge levels on the same issues, it appears that there is a certain degree of overlap between levels of knowledge and interest, implying that knowledge tends to trigger interest.

Assessed skills and interest to acquire more

Self-assessment of skills that are important for adopting IBR methodology was also carried out by respondents, as well assessment of their ICT skills.

In relation to IBL, students reported that they feel relatively confident in working as a team, doing fieldwork, embarking in problem-solving, keeping to deadlines and communicating verbally and in writing with others. Some variation has been observed between countries, with the Spanish students rating their confidence higher than other respondents, as seen in Fig. 2.
Regarding IT and digital literacy, all students show a high degree of confidence in using office software (word processing, spreadsheets etc.) and digital media (photos and videos) as well as smartphones and tablets. They also seem rather confident in playing location-based games. However, as expected, students do not feel equally familiar with GIS software, developing LBGs or interpreting satellite images to identify land-uses.

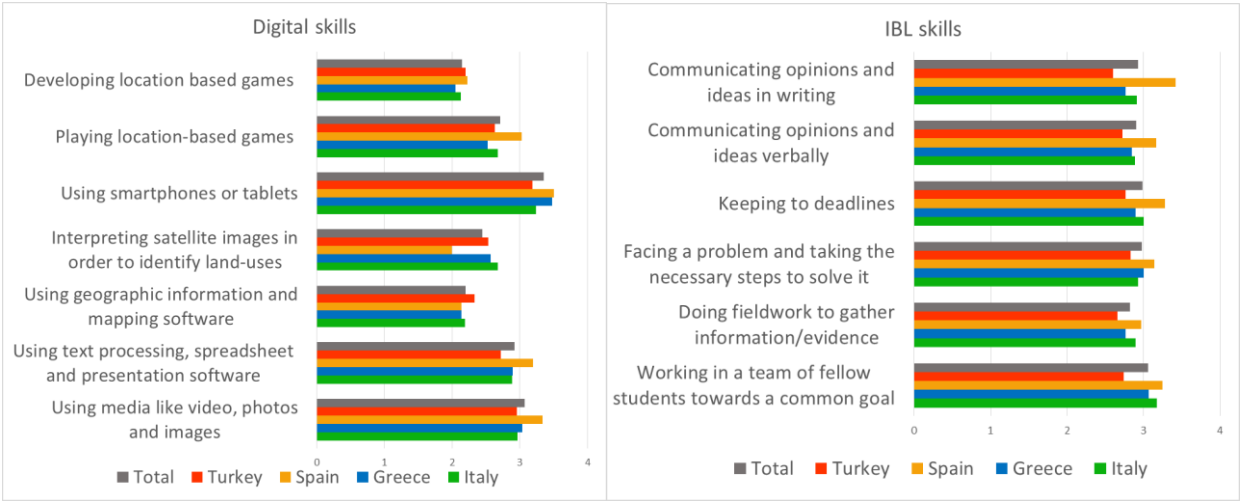

Figure 2. Level of self-assessed skills related to Inquiry-based Learning and digital skills

Students' interest in learning how to use the IBL methodology and such tools as GIS and LBG software was also explored and compared to their assessed levels of knowledge in these fields respectively. Regarding IBL, students appear to be strongly interested in such aspects as working on a project together with fellow students and experts, going on fieldtrips to gather evidence and embarking in problem-solving. Again, the reported level of interest reflects to a large extent the level of skills possessed. Interest is more varied regarding the use of specialized software and related skills, i.e. using mapping and GIS software or developing LBGs. Furthermore, we have noted a substantial difference between the overall higher levels of interest in two schools (Italian and Spanish) and the lower levels in the other schools (Greek and Turkish) in relation to aspects of the proposed methodology and the tools selected to implement it. This finding may connect to a fuller prior experience of students in Italy and Spain in project work and similar learning methodologies, as opposed to a more limited experience of students in Greece and Turkey.

Perceptions and attitudes

Students were invited to agree or disagree to certain statements related to the importance of the environment and the level of civic engagement towards its protection. Overall, students seem to be aware of the importance of environmental problems, and have a positive attitude towards the protection of the environment and the need to undertake an active role in this effort. However, in some of these statements we observe a relatively high proportion (30-40%) of students supporting negative attitudes, as can be seen in Fig. 3 below.

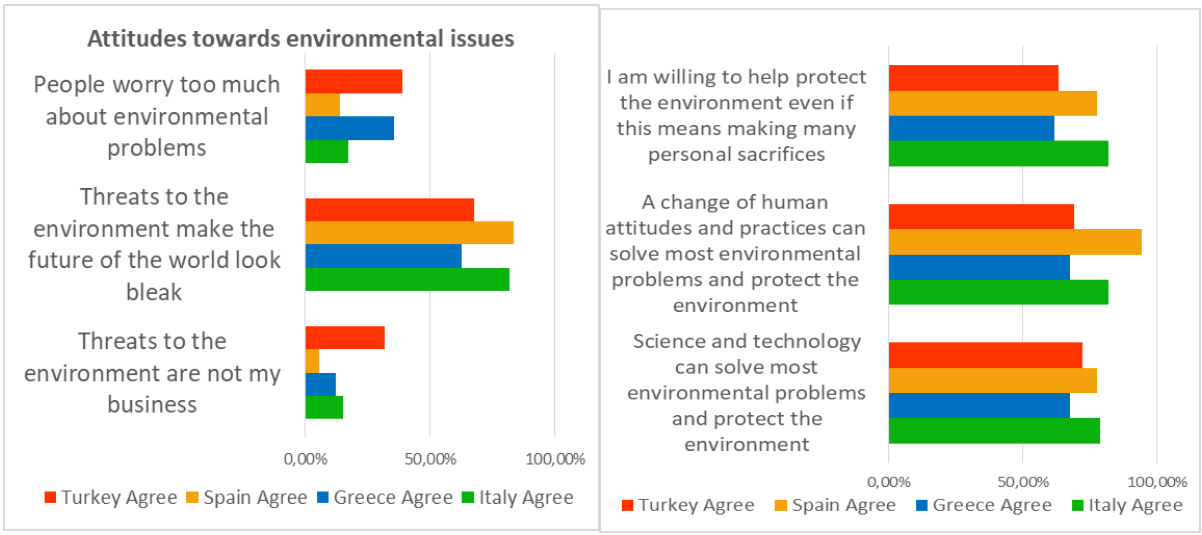

Figure 3 Endorsement of selected attitudes towards environmental issues

In particular, the statement “People worry too much about the environment” is supported by a rather substantial group in Greece and Turkey, while the statement “Threats to the environment are not my business” is supported by a similar group in Turkey. In all other statements, the variation between the participating locations is not substantial, although a trend among Italian and Spanish students to demonstrate more positive attitudes, compared to their colleagues from Greece and Turkey, can be observed.

Attitudes towards science and technology were also explored. The majority of the participating students (approximately 70-80%) demonstrate a positive attitude towards the importance of science, the use of new technologies in science education including educational games, and the connection of science to curiosity about natural phenomena. Overall, no substantial variation was observed across the participating schools. It should be noted, however, that 45% of the respondents in total reported science in school to be a difficult subject.

Finally, as an index of the students’ interest in environmental issues, and especially issues relevant to the theme of the project, information on extracurricular activities was gathered. The frequency of the respondents’ involvement in a preset list of activities, ranging from never (1) to very often (4) is shown in Fig. 4. Students overall reported a preference in watching a nature documentary on TV or in cinema, and visiting a science centre or museum, as shown by a relatively high frequency reported for these activities. Reading about nature and visiting a protected area came next as frequent activities, while they assessed their skill in reading a map rather highly. The mean value of responses per country does not indicate here a strong differentiation among survey locations.

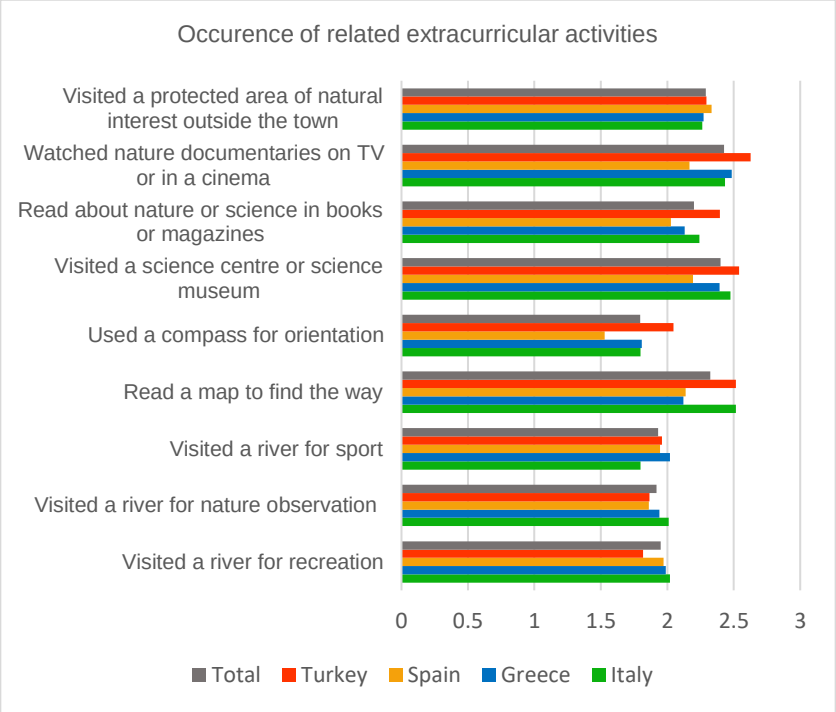

Figure 4. Students' involvement with extracurricular activities

Conclusions

The survey findings presented above draw a "snapshot" picture of the knowledge and skill needs, interests and attitudes of students of selected classes in 7 schools located in Italy, Greece, Spain and Turkey, which agreed to pilot test the IBL methodology in the context of a STEM approach, exploiting issues pertinent to "daylighting" covered rivers or to rivers facing the threat of being covered. The research findings helped the project team to adapt the IBL methodology to the needs of the students of the piloting schools and design the learning modules that have been used in the pilot testing so that they are relevant to the learners, helping them to develop further their multidisciplinary STEM knowledge and all-round environmental awareness. In this spirit, the main conclusions are stated.

We have noted the need of students to become more aware of important natural features of the urban environment in which they live, with prominent position given to rivers that either cross their cities and towns or are located near them, either open or covered. Our findings point out that such awareness, regarding rivers, is rather low among all students, although larger or smaller rivers cross the cities or towns of the surveyed schools.

The students have overall stated higher levels of knowledge regarding such aspects as the pollution and ecology of rivers, compared to other important aspects like the impact of climate change on rivers and the history of local rivers. This was partly reflected in the interest of students to learn more about these topics, demonstrating that knowledge generates further interest to learn. However, interest can be generated towards issues that students do not know a lot about, but are at the centre of current affairs and public discourse, such as the effects of climate change. This leads to the need to promote systematic knowledge of environmental issues at school, and in particular, use the Daylighting Rivers project to encourage and systematize such learning. Low levels of interest in learning about environmental issues related to river management have been observed in one of the participating countries, offering the opportunity to stress the importance of finding out about students' knowledge and interests, so that their awareness can be raised, and their interest on environmental topics can be stimulated by the school and teachers.

Regarding issues pertaining to covered rivers, the level of knowledge possessed by students appears to be substantially lower than that relating to open rivers. This has been expected though, because phenomena relating to covered rivers and their daylighting are rarely included in science teaching materials and usually, they are not high in the local agendas. However, such aspects offer great STEM learning opportunities, can cultivate critical

thinking, are ideal for IBL and favour an interdisciplinary approach to learning, including topics that are rarely included in the school curriculum, such as urban planning.

A particularly encouraging finding is that most students feel confident in implementing key activities of the proposed IBL methodology, e.g. performing fieldwork, working with a project team, communicating with others verbally and in writing etc.; and they expressed substantial interest in learning more about key IBL activities. More so, students expressed their confidence in using mainstream digital tools, although they excluded from such tools more sophisticated software, such as GIS, LBG development platforms and satellite interpretation tools, which of course, has been expected, given that such tools are more technical and specialized. However, in each country there is a group of students (22 in Italy, 15 in Greece, 13 in Spain and 50 in Turkey) who do feel confident in using the above specialist tools and their skills can be exploited to the best advantage of the class, assigning them a more active role in assisting their teachers and fellow classmates during the piloting of the proposed methodology. This is important, given the variation observed amongst schools regarding the interest expressed by students in these tools.

The attitudes of students towards the importance of environmental protection and the need for active civic engagement provides reassurance that environmental awareness exists at relatively high levels, although some variations are present amongst the participating schools. For example, students in Italy and Spain tend to demonstrate a more positive environmental attitude, while their colleagues in Greece and Turkey come up with a less positive attitude. Especially worrying is the emergence, in some schools, of significant minorities (30-40%) which believe that “people worry too much about the environment” or that it is not their business to be concerned about threats to the environment. This leads to the conclusion that the school has a definite opportunity as well as duty to reverse such attitudes and instill positive environmental values to students. This can be a particularly demanding task, given that the influence from the family and local or national community may not be towards such direction. In these cases, IBL and STEM can reveal the factual basis of environmental issues, using a hands-on approach and employing more than one school subject into an interdisciplinary explanation of environmental threats.

The survey findings demonstrate a positive stance of students towards science and technology subjects. However, around 45% of the students in total and similar proportions of students per country consider science in school to be a difficult subject. The integration of engaging and cooperative methodologies that employ ICT tools in science learning, as proposed by the Daylighting Rivers project, aims exactly at encouraging more school students to develop an interest in science and benefit from it.

Finally, we should note that most of the variations that have been registered between schools cannot be explained by an outside observer. Internal school organization and activities, local conditions, mainstream mentality concerning environmental issues, river management and urban planning, as well as current science teaching, may have influenced the students perceptions, interests and sources of knowledge. However, we believe that a survey like the one reported here can provide valuable guidance to schools for identifying learning needs and opportunities, in order to help students develop their own, well-informed and independent opinion and values.

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Rivers for civic ecology

Co-funded by the Erasmus+ Programme of the European Union

A NEIGHBOUR: THE ARNO RIVER. DIDACTIC PROJECT IN FLORENCE

Marinaro L.[1], Di Grazia S. [2]

[1]*Università di Firenze, Dipartimento di Architettura, Ass. Maieutiké, Italy, ludovica.marinaro@unifi.it*
[2]*Ass. Maieutiké -Via Niccolò da Uzzano 8, Florence, Italy, s.digrazia@maieutike.net*

Abstract

As art is a powerful landscape transformation engine, this artistic contest, open to young generation, aims to stimulate a new relationship with the Arno River, left aside the urban life and interest for too long. The educational project "Arno River: a neighbour" call to shape new visions and use perspectives of this resource including it in the core city life, as part of the educational strategies to trigger ecological and solidal transition of our development model.

Keywords: Landscape, river, city, school, creativity, landscape imagery.

The project and the final contest

School year 2019/2020 – Water Right Foundation and Publiacqua, in collaboration with the Council for Education of the City of Florence, have promoted the "*Un vicino di casa: l'Arno*" (A Neighbour: the Arno River) contest, aimed at primary and middle school students in Florence. Starting from the enhancement of the students' creative abilities, the goal of this competition is to raise awareness on preserving the water resource – the Arno river, in particular – and on its sustainable, responsible and proper management. The main themes were the managing and safeguard of water consumption, water footprint, the water cycle from a global perspective (climate change) and the relationship between water – and food – and health.

Figure 1. The Anconella potabilization plant in Florence. The water access to the plant ,

Each class had to carry out a creative group project focused on the river, where all the students were expected to work together (no individual entry was accepted). The participants used their creativity to interpret the theme they were given, and could present their work with various media, as text (poetry, narrative), images (comics, drawings, paintings, sculptures) or media projects (videos, short films, media content). A special Evaluation

Committee examined each project, rewarding the winners with vouchers to have access to educational material and supplies.

The relationship between Florence and its river is quite complex and, we could say, rich. The River can be seen as the main generator of the urban landscape morphology and it's one of the main features of the Florentine landscape structure. It divides the city in two parts, conditioning perspectives and toponymy, acting on the sense of places and People's sense of belonging. It has always been a fundamental presence, whose role oscillates between resource and threat. The city was born around the Arno, and this resource has been used for centuries, to provide sustenance (potable water, water for agriculture, etc…), to increase production and to facilitate travel. During the Renaissance, the river assumes a full infrastructural role, which has been maintained over the centuries. Florence became one of the main industrial centers, and great historians have described the city as the “Detroit of the 15th-16th century”. At that time, the river was already quite polluted, due to the production of textiles.

On the other side, the Arno, due to its torrential regime, has always caused devastating floods, which the most recent was in 1966. This double meaning of the river, it's double face, increase the complexity of the relationship with the city making it more "real", dynamic and alive. As a living system, with a functioning, a "character" and properties, the River invites us to recognise its identity and to rephrase our approach to its management as a resource and as a danger. This invitation echoes at international level in the communitarian rules and regulations, in the 17 Sustainable Development Goals (as for instance the 6.6 objective of SDGs), in the 2000/60/CE directive, and call us to provide urgent and effective measures to ensure the conservation of this important resource and it's ecosystems.

In the last years, much work has been done to improve water quality, with the construction of purification systems. The artificial lake of Bilancino, for instance, simplifies water regulation, and the Arno riverbed has been improved as to prevent floods. But since 1966, according to most part of the citizens, the Arno has remained dirty and dangerous.

The purpose of our contest is to bring the youth of Florence closer to their river, which should be perceived as a valuable member of their community, deserving of respect and friendliness. A first fundamental step is to observe it and recognize it's faceted role and meaning for the city, as the entire system of connections between the two.

The contest was presented with a speech by the Councilor for Education, Sara Funaro, who read unpublished letters from the 1966 flood. In these letters students shared their experience with the flood, which at the time were sent to Piero Bargellini – Mayor of Florence in 1966 and Sara Funaro’s grandfather –. These experiences are really relevant to show the fragility of this balance between Nature (intended as the River) and Human presence (the city), and the necessity to care about it. The 1966 tragedy seems so far from the imagery of younger generation now but we do not have to forget it, as we have to learn from the past, ensuring to not repeat the same mistakes. Acting on the imagery, and stimulating the creativity to nourish the landscape imagery it is very important in each educational process to cultivate design thinking, critical skills and initiative. Furthermore, this operation can stimulate to explore the river space once again, giving it back its role of public space capable to generate value. The works presented by the students are a great example of creative and concrete local educational activities on the relationship between young citizens and the river of their city.

The project “*Chiavi della Città”* (“Key to the City”) has contributed to our work, helping us successfully get schools involved. The award ceremony was part of the closing event for our Erasmus+ project “Daylighting Rivers”, supported by the City of Florence.

Figure 2. City of Florence and Arno River. In the foreground: the Anconella water potabilization Plant

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DAYLIGHTING RIVERS
SCIENCE EDUCATION FOR CIVIC ECOLOGY

Co-funded by the Erasmus+ Programme of the European Union

THE SCHOOLS OF MANTOVA FOR THE RIVERS

Sutti S.

LABTER-CREA Rete di Scuole, Laboratorio Territoriale-Centro di Riferimento per l'Educazione Ambientale, Mantova, Italy

Abstract

Progetto Mincio – a collaboration of students, teachers and community leaders in Mantova, Italy – was founded 30 years ago with the vision of studying and preserving the city's cherished waterways for future generations. Having been darkened by the industrial blight of the 1950s, when the discharge of pollutants ranging from petrochemicals to pig manure transformed Mantova's waterfronts from cultural treasures into dysfunctional wastelands, these rivers were in desperate need of daylight. The effort to reverse this ecological damage and reconnect the citizens of Mantova with its aquatic heritage was supported by a national network of government bodies, research institutions and environmental protection agencies, and from its inception until today has been spearheaded by local youth working on educational and practical activities both within and beyond the classroom walls. The most recent of these activities is the RIO Schools Project, which was designed in 2018-19 by three Mantova High Schools and launched just before the onslaught of the coronavirus pandemic, with a focus on the culverted Rio, the historical canal running through the heart of the renaissance-era city. This project was propelled by the annual "Rivers in Spring" event, promoted by Mantova's Labter-Crea School Network, the GLOBE ITALIA Association and other institutional partners in conjunction with the UN World Water Day – and this year's event was to focus on the issues of plastic waste and climate change, with its cancellation a stark symbol of the intersection between multiple environmental and human health crises. Prior to the pandemic, the schools involved in the Rio project monitored the water quality along the canal and discovered that contaminant levels had risen – a finding that even the local agencies were unaware of. In this paper, the recent evolution of the Mincio project and its diverse activities are described with an eye to the future of river protection, and a vision of resilience and dynamic action even in the face of global disruption and uncertainty.

Keywords: Mantova, Progetto Mincio, GLOBE Italy, school network, water quality monitoring, school-community collaboration, river protection

Introduction

The premise was triumphant: in 2020 we'd be celebrating the 30th (yes, that' s right!) edition of Progetto Mincio (Project Mincio, PM) and the 20th edition of World Water Day held in Mantova.

But then COVID-19 struck. The world stopped, as were the studies of surface waters in Mantova, and all other related activities run, managed and coordinated by Labter-Crea – the laboratory for the territory, and centre of reference for environmental education in Mantova.

COVID-19 did not have any respect for such a virtuous endeavour, started by Mantova's Schools in 1976 and that, in the thoughts of the proponents, should have never suffered from any censorship. Instead, censorship did happen and it took students, teachers, and local government bodies all by surprise. It generated bewilderment and disappointment for all the efforts and preparations gone up in smoke, and for the mobilisation that had been created and then vanished in a flash. The long months of COVID confinement have put our resilience to the test, but have also offered us an extraordinary opportunity to reflect on what we were doing and on possible new work paths to explore.Out of reflections with old and new partners emerged an investigative proposal, Microplastics in surface waters, accompanied by a brand-new protocol that will need to be tested in the coming months.

Best we go in order, though. We are aware that we have not made mention of events yet unknown to the reader, now opportune to describe. Unfortunately in Mantova we have not had the opportunity to resurface to daylight the

rivers and canals that were culverted in the past….therefore we feel we are out of theme or context. But then again…maybe we aren't.

1950 Postwar: poor houses and an environment to live

In the early post-war period, families were poor and their houses poorly furnished. We now have automated homes. We can manage our home and its functions remotely. Back then we kids had no idea. If it hadn't been for electrical illumination, our houses would have resembled medieval abodes. Nowadays we can connect worldwide with a click. With transport, there are few places on Earth we can't physically reach. With sufficient means, we can even arrange our own holiday in space. We can comfortably say that the world is within our hands', if not our wallet's, reach.

Back then, our arm's reach was restricted to whatever our little villages provided. The misery of our own homes forced us to live outdoors: winter, autumn and spring, morning and night. After doing our homework we'd play on the streets, or in the soccer ground or in the cultivated fields. But in summer….in summer we'd be going after the water: before sunrise we'd be out fishing and with a simple hook take home a swag of carp, catfish, eels, tench, chubs. During the day, we'd take brief voyages with improvised rafts or boats on waters of mythical flavour; but we'd take most enjoyment out of late afternoon swims, dips and dives from the bridge across the Gherardo Canal, where the best of the village's male youth would put on a show.

We said that our homes were bare, but our environment was really rich, unlimited and we lived life in full, with great intensity and joy; our environment was inside us, nature was our culture and defined our identity of kids "*poor but happy*".
Mantova, our city, is surrounded by three lakes, formed by the River Mincio. For centuries they have been the pride of the city, and their shores a place for people to gather. In the 50's things took a turn for the worst. An oil refinery, a petrochemical centre and a paper mill were established on the beautiful lakes of Mantova. They quickly introduced hydrocarbons to the waters and the fish, making the waters unsuitable for bathing and the fish for eating. The rapid process of industrial emancipation of the Mantuan society and of the entire Italian society had been highly anticipated and firmly sought, but as a bearer of wealth and riches. In the one fell swoop it instead deprived us of a precious source of sustenance, and of a priceless environment for us to live in and enjoy.

It was an anthropologically horrific strike: our rivers had not been culverted, but to us it felt as if they had been. We had been expelled from our beloved waters, and they would never come back.

Shortly after, it was intensive agriculture which tore to the ground trees that crowded our paddocks, and started to spread industrial quantities of agropharmaceuticals and fertilisers. Inexorably, the rains washed them into the canals. In parallel, industrial scale pig farming found it convenient to wash into rivers and canals the manure produced by a swine population that in a few years had become 4 times that of human residents in the region.

This shift in *our waters* from being a place of life to a place of smelly and toxic discharge determined the definitive physical and cultural distancing of my generation from our rivers and canals. They now had become only useful for sport-fishing of sick fish and for small boat excursions in waters *no longer our friends*. Then pools emerged, on the wake of USA fashion, as pale substitutes for lakes. Their arrival completed our cultural and physical deprival of our water ways. *Our rivers and our canals had been definitively culturally culverted.*

The examination that follows, focuses on water-centric projects, and the activities undertaken by the Mantuan Schools (Fig. 1). The endeavour has this substrate, which in fact has become their scope: *to resurface rivers, lakes and canals, bring them up into the light, bring them back into the culture and the lives of citizens. The last 70 years, characterised by the progress at all costs ideology and by unrestrained consumption, have substantially subtracted rivers, lakes and canals from the community's…..fruition.*

Figure 1. Pictures of the project Progetto Rio Scuole (2019).

As mentioned, over the years there have been many projects monitoring surface waters, and many activities. Both were run with common elements: collaboration, education and a drive for the common good. We remember among these: the activation of a network of schools, the huge support of local government bodies, the collaboration with environmental protection management and control agencies, the interactions with University institutes and research centres, particularly with Consiglio Nazionale delle Ricerche (IBIMET and IREA institutes), the giving data back to the citizenship through a publicly available Report on the State of the Waters. All these activities share key elements: 100% involvement of students in all phases of the activities, the high trustworthiness and reliability of schools in relation to times and commitments taken with the project leaders, the accuracy and precision in the execution of tasks, the assumption of responsibility by teachers and students, the sharing of moral gratifications, the considered use of resources, etc.

Figure 2. Data resulting from the chemical analysis of the urban river in Mantova.

The latest project to be born in Mantova is the RIO Schools Project. It was designed in 2018 and 2019 by three Mantova High Schools (IS Fermi, ITET Mantegna, IS Strozzi). It was launched in early 2020, but was immediately interrupted in its stride... Introducing this project requires a short premise.

2017, the RIO School Project

The Rio is a canal that divides Mantova North-East to South-West, linking the Upper Lake to the Lower Lake. The Upper, Middle and Lower are three intercommunicating lakes that surround the city of Mantova; they are formed by a widening of River Mincio, which originates at the Southern end of Lake Garda and joins the River Po after travelling 73 km in a Southerly direction. While River Po, the first river in Italy on both length and flow counts, crosses the province of Mantova West to East, River Mincio is the main river for the citizens of Mantova. Let's get back to the Rio. The canal was built at the end of the XII century, as a completion of the works designed and led by Alberto Pitentino, an architect from Bergamo, who aimed to fix the hydraulics of the city. The Rio was at the centre of everyday lives. Women would do their laundry in the Rio, which served as a commercial intra-city route, allowing to reach the "beccherie" (meat market), the "pescherie" (fish market) and the jewelleries that were once at the edges of the city centre. The canal became the new city boundary, but not for long, as the city quickly expanded. Over time the banks of the canal became enriched with important buildings: the well-renowned convents of Saint Francis and Saint Dominic (demolished in the 1900s) and the complex of the Pescherie (fish markets) designed by Giulio Romano in 1536. It must have fascinating to watch life unfold, while strolling along the Rio, which even now offers highly suggestive views. Unfortunately, at the end of the 1950's, it was decided that a part of the Rio canal, that now known as '*Corso della Liberta*', be culverted, to make room for a road that would speed up connections between two parts of the city.

That moment marked the start of the decline of the Rio, which silently exited from the lives of the citizens of Mantova: only 200 m of the canal were culverted, but it felt like the whole of it had been removed from the sight of Mantova's citizens.

Some of the characteristic surrounding buildings were abandoned to their fate. For the last few years, the philanthropic foundation "Le Pescherie di Giulio Romano" has been hard at work to restore and return to the citizens and visitors of Mantova the *Pescherie di Levante di Giulio Romano* (Eastern Fish Markets by Giulio Romano – inaccessible for many years), and the access to the banks of the Rio and to the portico of the Beccherie (meat markets) located right beneath the fish markets (which are at street level instead). This foundation aims to rescue this renaissance heritage of incredible value from decline and private speculation. It aims to bring back to the attention of the public the relationship between the historical city centre and water, a relationship that characterises the city of Mantova in a unique way. The Foundation is not the only body putting efforts towards this. In 2016, the "*Friends of Palazzo Te*" association, in collaboration with the Mantova City Council, organised short boat excursions on the Rio canal, to entice people back to the Rio. With over 5,000 participating tourists and citizens, the initiative has had great impact. The road of citizen engagement is the right one to follow. But how do schools relate to a project of historical-architectonic requalification? To answer this legitimate question we need to digress for a short while, to then go back to Progetto RIO.

2001-2019, *Rivers in Spring*, World water day in Mantova

Rivers in Spring (Fig. 3) is a huge event, held on the right banks of the lakes of Mantova. Over 3,000 students, teachers and citizens take part. Since 2001, without interruption, it has been typically held on March 22nd, the official date set by the United Nations for World Water Day. It's a vivacious and colourful event, filled with creativity. Innovative proposals in terms of scientific and creative didactics are offered by the 60 posts, situated along the banks of the Lungolago Gonzaga, managed by the Schools and their partners.


la Voce di Mantova

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Oltre 3000 ragazzi per salvaguardare il bene dell'acqua

Figure 3. Students engaged in Rivers in Spring festival in Mantova.

The event is the fruit of a process of participated design, promoted by Mantova's Labter-Crea School Network and by the GLOBE ITALIA Association, together with the ISS Bassa Friulana di Cervignano del Friuli (Province of Udine, Italy) and the network of Italian schools linked to the GLOBE Project. It also features institutional partners such as Regione Lombardia (Regional Government), the Province and Council of Mantova, Parco del Mincio and Parco Oglio Sud, as well as a long list of other partners among which are schools of every level, environmental, health and forest protection agencies, the Interregional Authority for River Po, the Emergency Services, and other associations, agencies, companies and many keen citizens.

"*Schools call and society answers*" is the motto of the event, justified by the fact that schools are the event's propulsive force, but the network of participating individuals and private companies is fundamental: the support they provide in terms of resources and logistics is critical to the success of the event.

Each year United Nations Environment Program launches a theme. The 2020 theme is Water and Climate Change. The organisers of Rivers in Spring activity usually accompany the UN theme with others of local or general interest: *the Contract of Mincio River, The Right to Water, Water and Agriculture, Water-Energy, Water and Employment, Integrated Water Management, Water and Plastics*. The 2020 edition would have been the first "Plastic-free" World Water Day event. No single-use plastics were included, and events monitored for CO_2 emissions, in agreement with the C-Change EU project, managed by Mantova City Council for its Italian chapter. Unfortunately, COVID-19 prevented participants from engaging with it in full in 2020 and we look forward to opportunities in 2021.
The celebration of World Water Day wants to promote a holistic culture of water and environment, as opposed to an "emergency" approach, and give continuity to a project that develops in the citizenship a keenness to be active participants and sustainable managers of the territory.

Why talk about WWD? During the 2017 edition, Paolo Corbellani (MEng), President of the "Le Pescherie di Giulio Romano" foundation, proposed that the high schools of Mantova, which have an enviable rich pedigree of decades of studies, investigations and defence of the local waters, run an a water quality campaign along the length of the Rio. The request has a solid motivation: within a few years, the citizens will be able to access the renaissance portico of the Beccherie, a place of great suggestive appeal that is located at the edge of the water. It's important to make the experience a safe and positive one. The visitors would be able to sip a coffee at one of the tables upon a new platform, placed where women once did their laundry. These walks along the portico, and stops by the bar, would not be very comfortable should the waters be unhealthy.

2017-2020, Back to RIO School Project

ITET Mantegna and IS Fermi, schools historically involved in environmental education activities, welcome the Rio water monitoring campaign proposal with enthusiasm (Fig. 4). Just a few meetings are necessary to define the details of the operation, to be managed in the context of the "Alternating School and Work" scheme together with the Foundation "Le Pescherie di Giulio Romano". The investigation involves also Mantova's divisions of the Lombardia Environmental Protection Agency (ARPA), the Valpadana Agency for Health Protection (ATS). This marks the birth of the RIO School Project, officially inaugurated on 10th February 2018. The schools ran two monitoring campaigns in 2018: one in winter (February) and one in spring (April). The results highlighted small increments in available nutrients (nitrates and phosphates) along the length, and a definite increase in the concentration of Escherichia Coli and Enterococcus in sampling stations number 5, 6, 7 and 8. The data was further confirmed by summer and autumn monitoring campaigns by ARPA and ATS, which support the data collected by the Schools. The investigation was repeated in 2019, with the addition of a third school (IS Strozzi), and confirmed the previous results. The results are puzzling as there is no justifiable theory to support the worsening of the quality of the waters along the length of the Rio, as domestic sewerage in Mantova should all be already connected to the underground sewer network…but then again, the data reveal that there must be polluting inputs between the start and the end of the canal.

Figure 4. Students engaged in scientific investigations about the river water quality.

Never before had a systematic analysis been run on the waters of the Rio. This has happened in this project thanks to the collaboration between schools, environmental control agencies and local government bodies. The investigation has revealed that there is a problem along the canal that the local agencies were unaware of. The schools have helped to uncover the problem, but have no mandate to solve it. This is where working with government and local bodies is fundamental in achieving impact.

2018-2020, From RIO School Project to "RIO Panel"

In parallel with the investigations run by the schools and government bodies, many meetings are held among the Mantova society's stakeholders. Initially, the events are catalysed by Labter-Crea and the Foundation through the RIO School Project, with the ambitious project objective to bring the Rio back to being the centre of Mantova's cultural life. At a later stage, the Mantova City Council also contributed to bringing more relevant parties together, by proposing the "Rio Panel", a panel of representatives from local government, as well as from companies, agencies and associations for the control, management and defence of waters, the environment and public health. The panel has a clear and official mandate: to define, initiate and complete a virtuous process of active citizenship that involves subjects of various natures connected by interest for the common good; the scope of the process is to reach short, medium and long-term objectives related to Rio Canal." (Comune di Mantova, 2018).

On 29.03.2018, the "Panel" was presented at a press conference held in the Mantova City Council rooms. Eleven subjects take part in the "Panel", eight of which are public. Among the latter two key High Schools for the project: ITET Mantegna and IS Fermi. Later, one further high school joined (IS Strozzi Mantova) along with many associations.

NASCE IL TAVOLO DI LAVORO

Una nuova vita per il Rio Monitoraggio sull'acqua

Una via d'acqua in città: la presentazione delle iniziative sul Rio

Dare nuova vita al Rio. Con questo obiettivo nasce un tavolo di lavoro formato da istituzioni, enti e scuole: Comune, Regione, Soprintendenza, Fondazione Le Pescherie di Giulio Romano, Labter-Crea rete di scuole, istituti Mantegna e Fermi, Gruppo speleologico mantovano, Arpa, Aipo, Ats Valpadana, Consorzio di bonifica e Tea. Ieri mattina il primo incontro preceduto dalla presentazione dell'iniziativa da parte di Andrea Murari, assessore comunale all'ambiente, Paolo Corbellani, presidente Fondazione Le Pescherie e Sandro Sutti, referente di Labter-Crea. Tra gli interventi in programma da portare a termine entro i prossimi tre anni: la valutazione e il monitoraggio delle acque e una ricerca storica, artistica e culturale del Rio recuperando documenti, informazioni, foto e video da enti pubblici e privati. Tutto il materiale sarà caricato su un sito web dedicato.

Ma tra i progetti ci sono anche l'istallazione di un sistema automatico di paratoie a valle con azionamento a distanza e interventi di restauro della struttura del canale e di pulizia con la rimozione di ingombranti e di alghe. Infine si pensa al ripristino delle mini crociere.

«L'idea di intervenire sul Rio è partita un anno fa– spiega Corbellani– si inserisce nel lavoro che la fondazione Le Pescherie di Giulio Romano sta portando avanti per riqualificare le Pescherie di Levante. Un intervento che prevede anche un accesso permanente al livello dell'acqua riaprendo un passaggio bloccato da decenni e la realizzazione di una terrazza-pontile sul Rio».

A giugno saranno presentati i risultati delle analisi
Nel progetto triennale anche una ricerca storica artistica e culturale
Si punta a ripristinare le mini crociere

I lavori che riguardano l'indagine chimico-fisica batteriologica delle acque sono già partiti col progetto di alternanza scuola-lavoro "Rio scuole". Sul campo i ragazzi del Mantegna e dell'Itis. A inizio febbraio gli studenti hanno fatto un primo sopralluogo nelle otto stazioni scelte per il monitoraggio. A fine febbraio ha avuto poi inizio la prima campagna di indagine che proseguirà il 12 e il 14 aprile. Il 5 giugno incontro finale con la presentazione dei risultati che saranno incrociati con quelli riscontrati da Arpa che da aprile 2017 sta analizzando l'acqua con campagne mensili con sonda parabolica.

Per far riavvicinare i cittadini all'acqua, il 12 maggio sera è in calendario una proiezione di filmati proprio sul Lungo Rio curati dall'associazione Amici di Palazzo Te. Tema: Mantova città d'acqua.

Il Tavolo del Rio, per i prossimi incontri, vuole allargarsi chiamando ulteriori stakeholder. Chi è interessato a partecipare può scrivere a sandro.sutti@gmail.com

Barbara Rodella

Figure 5. Conference press for the creation of the "Rio Panel".

The aim of the "Panel" is facilitate bringing the Rio back to be at the centre of city life, by requalifying it and catalysing its cultural, functional and environmental recovery. In step with its role, the cooperation of participants to the "panel" is to be intended as the expression of an Agenda 21 with a local and multi-value focus. The Table co-design and co-manage a path of actions, investigations, research, and experimentation orbiting around the Rio Canal. All participants act within the strategic planning spirit described in the premise, and must be consistent with the broader frame of the Contratto del fiume Mincio (see below).

During 2018, the fast initial progress is somewhat brought to a stalemate due to bureaucracy and unforeseen difficulties. In 2019 Mantova City Council tries to re-launch the initiative. By working together with TEA Spa (local multiutility agency), the Council plans thorough cleaning of the canal's bed. And here is when we come to 2020…

2020 should have been the year for a turn of the page for the Rio: visiting each household that look over the canal, Tea would have been able to investigate illegal grey and black water dumping (considered likely culprits of the unexpected pollution), fine the perpetrators, and finally facilitate their connection to the city's sewer network. These are only a few of the ameliorating interventions programmed for 2020. COVID-19 suddenly brought all these actions to a grinding halt.

The moral of the Rio Project story is simple and is of daylighting its role in the community: a cultural-focus Foundation enacting architectonic requalification along the canal enlists the local schools for help monitoring the waters of the Rio, with Labter-Crea in a coordinating role. Once again, the sum of the many parts delivers more than expected. Together they see the possibility to broaden the project objectives. With a broader scope they then involve a very healthy list of new-entries: associations, agencies, and Council administrations with the common aim to achieve the recovery of the canal on many fronts: architectural, cultural, economic and environmental.
Schools interweave their actions with those of the community and become agents and drivers of change.

2016, The River Mincio Contract: the school officially becomes environmental stakeholder

The River Mincio contract is a formal artefact that facilitates the bringing together of stakeholders with many diverse interests. The contract is a negotiated programme for the requalification of River Mincio. It's subscribed by 60 government bodies (Regions, Provinces, Councils) and associations operating in the Mincio River Catchment as of 18th May 2016. Among these, the Labter-Crea School Network, representing the 15 schools of the network (High Schools and Comprehensive Institutes). The Action Programme in the Contract encompasses over 60 actions, under 9 theme areas. One area is the Environmental Communication and Sensitisation. It includes World Water Day actions, the Progetto Mincio (Mincio Project) and welcomes the Rio Project 2 years into the contract.

Labter-Crea facilitates the entrance of schools in the Rio Project, putting them at the centre of a process of environmental requalification of a water catchment with a portfolio of studies, communicative investigations, and sensitisation actions. This is a first in Italian schools and possibly also internationally.

What have schools done to cross the purely educative framework, even if scientific in nature, and become environmental stakeholders? As of 2016, the answer to this question lies in the way they have managed the Mincio Project, created Labter-Crea (1996), activated and coordinated GLOBE Italia (1998) and, even earlier, established the WAP Project (Water Analysis Project 1976-1990). 31 years of uninterrupted activity of studies, scientific investigations, educational programmes, conferences, and field-camps in scientific education applied to the environment, with a particular focus on the hydrosphere, communication and citizen sensitisation towards the environment.

1997-2020, the GLOBE Program and the GLOBE Italia network

In 1997 the Ministry for Public Education (MPI) and Instruction adheres to the GLOBE Program, "an international programme of science and education that offers students and the public worldwide the opportunity to participate in data collection and scientific process, and to contribute in a significant manner to the comprehension of system Earth and global environment. Launched by the U.S.A. Government in the occasion of World Earth Day 1994, GLOBE launched its world-wide implementation in 1995" (US Government, 2020) Once sign-up to GLOBE was completed, it is necessary to establish the network of schools that needs to enact GLOBE proposals. This task was given to Labter-Crea's scientific coordinator who, together with a referent from the Ministry, selects 30 schools across Italy, to represent nearly all regions. Key participant schools are ITIS Fermi (Mantova) and ITIS Malignani (now ISS Bassa Friulana, Cervignano del Friuli). They collaborate very closely and have been for years at the forefront of scientific education applied to the environment. These two schools will bear the weight of coordinating the Italian network: after the initial enthusiasm of the MPI-organised courses, the Ministry engagement waned, and MPI formally and practically abandoned the project in 2001. The responsibility for delivering high-quality courses at the regional, national and international level (run in 2008, 2011, 2014 and 2019) was taken over by Labter-Crea initially, followed by ISS Bassa Friulana in the last few years. ISS Bassa Friulana is led by a team of very enthusiastic, energetic, informed and visionary teachers, with unparalleled management abilities: Lorella Rigonat (Country Coordinator), and Deputy Country Coordinators Paola Zanon, Graziella Mocellin and Maria Pia Coceano. They are well renowned for environmental education crowd initiatives, among which World Earth Day (22nd April) and "At School on the River". These teachers mobilise local government agencies, research centres, environmental protection agencies and a myriad of volunteer associations that over the years have assumed a key role in guaranteeing and managing the structural and logistical services that allow these activities to take place. Coordination of the volunteer associations is the hands of another immensely important human resource, Dott. Fabio Rivolt.

For Labter-Crea and the Schools of Mantova, GLOBE means the ability to interface with a new world of educational and collaborative scenarii. GLOBE has been a unique opportunity to be involved in an oustanding managerial education system. Through GLOBE, Labter-Crea and the Schools of Mantova become fully internationalised – connected with schools and educational networks across the globe. The path to reaching beyond Italian borders has been long. It started in the 80's and then continued in the 90's with the GREEN Project and TEMPUS Project. This latter project, led by Kiel's IPN (Germany) and King's College London (UK), achieved the updating of university curricula in Eastern Europe through the addition of ICT (Information Communication Technologies).

It is thanks to this international engagement that Mincio Project first, and Labter-Crea later were created.

1990-2020, the Mincio Project: a network for the rivers

In 1989 Michigan University passed to ITIS Fermi the responsibility to coordinate the Italian network of GREEN, the Global Rivers Environmental Education Network. GREEN, the brain child of Michigan University, has been established in over 100 countries world-wide since its launch. GREEN proposes an evaluation index for surface waters – the Water Quality Index. This index is calculated by normalising data from nine analysed parameters (eight chemical, one bacteriological). GREEN provides a very detailed protocol for each analysis, all contained in a Field Manual, which is an exemplar of how methodology should be deployed in the field.

The approach is really clever: a comprehensive quality evaluation of surface waters can be obtained through somehow simple tests that can be performed on the field and can be further complemented by laboratory activities at school (Fig. 6).

Figure 6. Photos of the practical activities performed to monitor and assess the water quality.

While this is no place to discuss the benefits and drawbacks of the GREEN Project, it's important to note that this simple and bright approach provided the High Schools of Mantova (already involved in the WAP Project) the key to start to engage with the local Middle Schools (years 6-8). This started the Mincio Project, within which Middle and High schools from all over the Parco del Mincio found common ground monitoring their river. The idea was warmly welcomed by teachers of the 5 WAP High Schools and by 30 or so teachers of the Middle Schools located within the 13 Councils of the Parco del Mincio.

Teacher training took place in September 1990. In the early months of 1991 all classes involved in the Project are trained in the chemical laboratories of ITIS Fermi. The students learn how to use analysis kits and instruments under controlled conditions. In May all Middle Schools are provided with all instruments and documentation necessary to complete the analyses. On 17th May 1991 all schools involved in the project get to work at the 9 monitoring and sampling stations along river Mincio. The ample media coverage highlighted the uniqueness of the event on the global scale. Even greater is the coverage of the results of the analyses. These are distributed to the citizenship of Mantova, as formally agreed with the stakeholders and local government agencies: the Province, the local Councils and the Parco del Mincio. The Mincio Project framework sees year 8 students focus on the chemical/bacteriological investigations, year 7 students on the microplankton analysis (later replaced by the macroinvertebrates – since microplankton analysis is more suited to stagnant waters and macroinvertebrates analysis to running fresh water bodies), and year 6 students on the analysis of flora and fauna on the shores. The model of horizontal and vertical school networks thus demonstrated encourages participation by a growing number of students. The first few years are exhilarating: the monitoring and sampling stations grow from 9 to 12, more than 1,000 students become involved in the various phases of the project, teacher meetings grow, and the various organisational levels and tools are refined. The originality and breadth of the project attracted the attention of international and national agencies. After just a few years, the Progetto Mincio schools are visited and studied by many foreign researchers. Many international conferences, training camps and courses quickly add to the project's activities. The coordinator of the Progetto Mincio is co-opted as international expert for the TEMPUS

European Projects, aimed at revolutionising tertiary education study curricula in Bulgaria, the Czech Republic and Lithuania. The success of Mincio Project is astonishing, the model is replicated in other Italian regions, even if on a smaller scale. It's the success of Mincio Project the key to the sudden jump in quality that led to LABTER-CREA only just a few years later.

1996-2020, LABTER-CREA: The metamorphosis

The *Network for Territorial Laboratories for Environmental Education* (LabNet) was established in Rome in 1994. The author, as coordinator of the Mincio Project in contact with the creators of LabNet, designs a project for a Territorial Laboratory (Labter) in Mantova. For more than 1 year, the idea is worked on by Mantova's Province and Council, the Department of Education and ITIS Fermi, the key school of the Mincio Project. The agreement is signed in 1996, assigning the scientific-coordinator role to the author. Twenty years to the day had passed from ITIS's first steps in environmental sciences; twenty years of 100% effort, on the basis of spontaneous coordination and management, born from a shared vision and values of educational pathways and scientific education applied to the environment, in the environment and for the environment. Twenty years have gone by, but they were worth the effort, as they led to the founding of the Laboratorio Territoriale, the structure that was felt now needed. The same structure that would allow a jump in quality for environmental education in Mantova. The jump in quality takes place. Relationships with Universities and research centres are strengthened, as are international relationships. This catalyses new training courses for new investigation areas (lichens, macroinvertebrates in the soil, arid fields, etc.). These courses in turn spark new projects (with the same theme), each managed by a network of schools. The definitive impulse comes with the two scientific coordinators, Massimo Codurri and Cesare Martignoni, who will replace the author in 2004 and 2008 respectively. Field and laboratory manuals are created and printed with national distribution, for: i) water monitoring (MENS 1996 (Sutti, 1996) and "A fior d'Acqua" 1996 (Prigge and Sutti, 1996), update to MENS 1999 (Sutti, 1999) and "Progetto PO: actions, chemical-bacteriological monitoring of the rivers for a sustainable development" 2003 (Sutti, 1999)), ii) lichen coverage and distribution (Symbiotic Relations, from Lichens to the local Agenda 21, 2002 (Valcuvia et al. 2003)), and iii) for the recognition of flora and vegetation in the wetlands of the Pianura Padana 2008 (Persico and Truzzi, 2008). The fingerprint of Labter-Crea is clear: i) in the birth of the GLOBE Italia Project, in the "Progetto un Po di cultura" (1997-2003) and in the demonstration of hydrogen fuel-cell vehicles in Mantova within the Zero Regio European Project (2005-2010). It's also thanks to Labter-Crea that the well-renowned Rivers in Spring, Mantova World Water Day event, starts.

The Mincio Project laid the foundations for Labter-Crea. But what laid them for the Mincio Project?

For this report the question will remain unanswered for two reasons. One: to remain within the limits offered by the organisers. Two: invite those of you whose interest might have been tickled by our story, and might want to hear its end, or rather how it all started.

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*Labter-Crea scientific coordinator, GLOBE Italy Country Coordinator

Urban river stories: daylighting rivers and awareness

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LOST RIVERS OF ANKARA AND THEIR USE IN ENVIRONMENTAL EDUCATION

Karaarslan-Semiz G.[1*], Semiz Y. [2] Özdamar E.D.[3]

[1]*Ağrı İbrahim Çeçen University, Department of Math and Science Education, Ağrı, Turkey, gulizkaraarslan@gmail.com*
[2]*Luwi Film, Ankara, Turkey, ysemiz@luwifilm.com;*
[3]*Middle East Technical University, Department of Chemistry, Ankara, Turkey, eozdamar@metu.edu.tr,*
**corresponding author*

Abstract

Ankara is a city which became the capital of some ancient civilizations in the history and has been the capital of Republic of Turkey since 1923. In this study, the story of Ankara's lost rivers that have been culverted for 60 years will be presented. The city is generally known as grey and arid because it has not any seaside. However, this is a misconception, since it has many streams. Historical centrum of Ankara has been settled at the intersection of three rivers and 67 streams and many of them now flows under the roads due to the flood problems, pollution and growing of the city as the population increased. Besides, the residents of the city are not aware that they are actually passing over underground streams as they walk through the streets and avenues of Ankara every day. The documentary "Under the road, the river!" is produced in 2019 tracing the lost streams of Ankara and shedding light on the struggle to bring these streams back to the daylight.

This study covers how the documentary was created, the research studies about lost rivers in Ankara and how possible daylighting the rivers in Ankara in the current times. At the end, the authors will discuss, how to establish a bond between young people and the lost rivers of Ankara; raise their awareness and inspire them to be part of the change.

Keywords: lost rivers, daylighting rivers, young people, environmental education and urban planning problems

Introduction

Ankara has been a historical city at Anatolia, Turkey which was also known as Ancyra or Angora at ancient times. It was the capital of Galatia, and crossroads of many civilizations like Roman, Hittites, Lydian as an important commercial center. (Galanti, 1950). The city has been also known with its streams since it is settled near the Ankara River, confluence of the Hatip, İncesu and Çubuk streams.

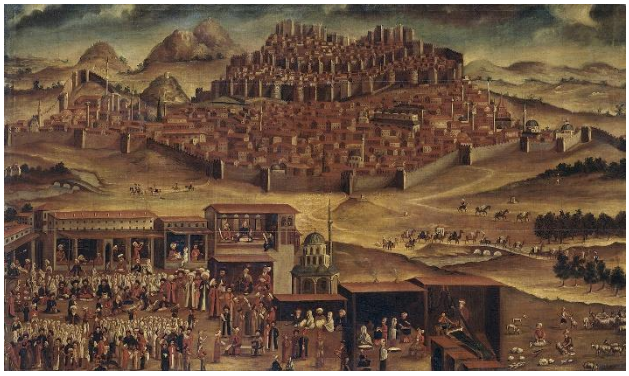

Figure 1. Landscape of Ankara 1700-1799 ; Rijksmuseum

The city became the capital of the newly founded Republic of Turkey in 1923. One of the first urban planning was drawn by Herman Jansen, stressing the importance of green belts, and gardens and rivers. At that time nearly 20.000 residents were living in the city. The population has grown more than predicted, and in 2020, about 6 million people live in the city. After 1950s due to pollution, floods and growing population, the rivers are mostly

culverted. In addition, the rivers long-time exposure to sewage and industrial pollutants, they are no longer viable as a fresh water source for irrigation, even though it is still used for irrigation downstream. Nowadays, we can follow the trace of streams only at signboards. Documentary is about this historical aspect and residents of Ankara.

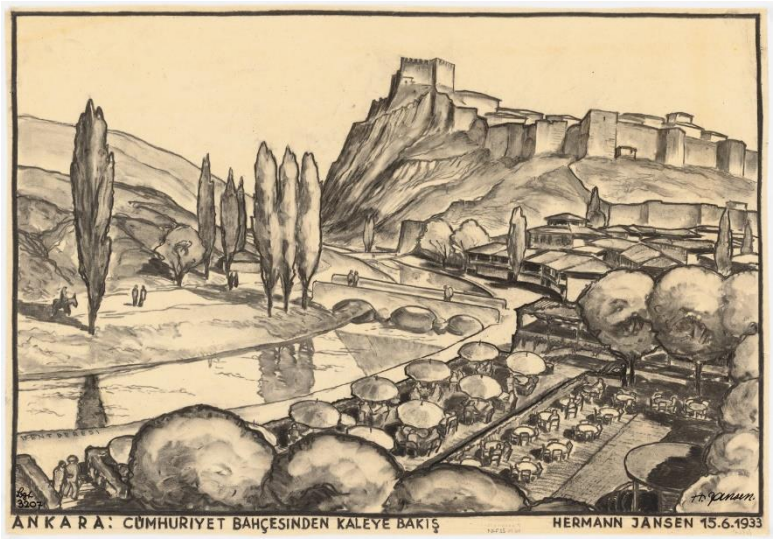

Figure 2. Ankara city centre, Hatip River region, Herman Jansen city plan (Goethe-Institut, 2010)

Methodology

The production process of the documentary includes 6 months of research. Old photographs, old maps and video footage is collected. An extended literature review about history of Ankara and its rivers is done. The book written by Erman Tamur “Suda Suretimiz Çıkıyor *(Our images are in the water)*” is used as a reference book.

The first part of the documentary is about the history of the city with interviews of inhabitants, academicians, activists whose names are given below.

The name of the documentary “Under The Road, The River” refers a *cri de coeur* used in Paris’ 1968 student protests, “sous les pavés, la plage!" (under the pavers, the beach!). The idea is if we demolish the roads above the rivers and daylight the rivers we can have a better world.

Documentary independently funded by Yasin Semiz. He applied to some documentary funds such as Republic of Turkey The Ministry of Culture and Tourism documentary fund but they were rejected. So in 2016 an “Indiegogo” crowdfunding campaign is started, so this documentary can be considered as a low budget production.

Figure 3-4. (Left) Yasin Semiz near Hatip River – (Right) Elçin Deniz Özdamar while research at Mimarlar Derneği 1927

Hasan Akyar is the main story teller of documentary, he is a civil engineer telling people the stories of the lost streams of Ankara. He has worked at DSİ (State Hydraulic Works) for many years. In this screenshot he talks about lost streams Ankara near manhole cover over Kirazlıdere Stream.

Figure 5. Hasan Akyar – from Under The Road, The River! Documentary.

At 1957 a flood is happened and many people died. An old footage is found of this catastrophe, it is the only video of this incident and it is the first time showed. At that years, flood, pollution and growing population streams began to culvert.

Figure 6. River culverting – from Under The Road, The River! Documentary.

In 2000s most of the streams in city center were culverted. Onur Bektaş who is a civil engineer also gathers old maps, photographs and traces the rivers. On the left figure new maps are created from old aerial photographs can be seen on pc screen.

Figure 7-8. Onur Bektaş tracing the rivers - from Under The Road, The River! Documentary.

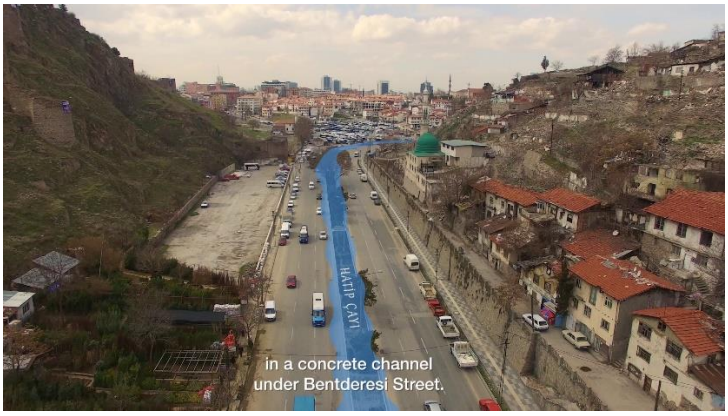

Figure 9. An animation shows the trace of Hatip River under Bentderesi Street - from Under The Road, The River! Documentary.

At 2015 a photograph exhibition is done to gain public awareness.

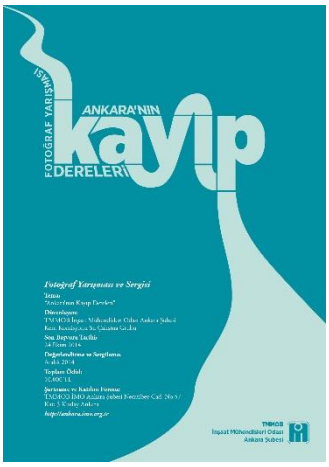

Figure 10-11. Photo exhibition about the lost rivers of Ankara – from Under The Road, The River! Documentary.

Ahmet Soyak is a flâneur known as “city explorer” in Ankara. He travels all around city, take photographs and videos and shares them via Youtube and Facebook pages. In the documentary audience witness the stories of rivers with him.

Figure 12. Ahmet Soyak looking underground part of Dikmen Stream - from Under The Road, The River! Documentary.

İdil Börtücene is a performing artist who performs her show as “lost swan” in the Dead Nature of Ankara event.

Figure 13. İdil Börtücene performing Lost Swan - from Under The Road, The River! Documentary.

Duygu Cihanger is a PhD. student, now an academician uses a blue cloth to show Kavaklıdere Stream passing under the Tunus Street.

Figure 14. Duygu Cihanger tracing lost water - from Under The Road, The River! documentary

Some underground shots have founded at the Ankara Water and Sewerage Administration (ASKİ). These footage was used and rivers under roads in dark can be seen.

Figure 15. Closed part of Hatip River – from Under The Road, The River! Documentary.

Documentary is finished at 2019 after nearly 5 years of work.

Results

The documentary is screened at several film festivals in Turkey such as, İstanbul Film Festival and Ankara Film Festival and Antalya Golden Orange Film Festival which is a well-known, mediatic, prestigious and the oldest festival in Turkey. Documentary won some prizes also such as VEKAM Special Prize, in Ankara Film Festival.

Documentary induced some academic and political areas by expanding the awareness. Referred in some articles, viewed on some conferences. Ankara Municipality had some meetings on the subject and began to work on some projects about the lost rivers.

As the result, it can be concluded that documentary filmmaking may be a method for expanding the awareness and to form public opinion, as a model for other cities.

Some education programs can be planned in the future, in order to gain awareness of young people about tracing the lost rivers.

Discussion and Conclusion

How the lost rivers story can be used in environmental education?

In order to increase students' awareness and develop their connection with the lost rivers of Ankara and this real story can be used as a learning resource in environmental education.

Problem based learning, project based learning and place based learning are effective learning strategies that we can use with our students to engage them in this real story (lost rivers).

Through problem based learning, students can explore the lost rivers problem and their impact on the city (climate, social life, urban planning, pollution etc.) They watch the "Under the road, the river" (2019) documentary and they analyze and discuss this documentary. They can search secondary resources and interview with community members and scientists to get more information. They learn how the city changed over time and compare the differences between the past time of the city and current times. Moreover, they understand how the rivers were lost in the city because of growth of the city and urbanization problems. They also discuss the solutions. They can look at the reports, articles, videos and collect empirical data such as by interviewing with the scientists and measuring water quality. While looking for solutions, project based learning can be used. Students can explain their vision of the city and make a plan for daylighting rivers. They can create a small scale model of a sustainable city by considering transportation, environmental management, green energy and restoring rivers of the city. This story is also a part of place based education as students work on a local problem and discuss solutions to improve their local environment. Thus, we can increase students' sense of place. Lost rivers story is a systemic problem and therefore, we need to find systemic solutions. From the education side, this story can be integrated to multiple disciplines to increase students' knowledge and awareness about the lost rivers and inspire them to be change makers for creating a sustainable future.

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THE ST. PIERRE RIVER: REMEMBERING A HISTORIC MONTRÉAL WATERWAY

Legault, L.

Les Amis du Parc Meadowbrook, Montréal, Canada, lesamisdemeadowbrook@gmail.org

Abstract

A Montréal environmental group, Les Amis du Parc Meadowbrook, has been protecting one of the last remaining sections of an historic waterway, one that has both witnessed and shaped the development of Montréal. The recent history of this waterway, the St. Pierre River, is typical of the evolving relationship between the population and urban waterways: what was once an advantage, with these rivers providing transportation and fresh water for agricultural use and human and animal consumption, then turned into a major nuisance with increasing pollution from growing industrialization and urbanization (Deudon 2012). The 19th century solution was to integrate and bury the St. Pierre River into the sewer system.

Les Amis du Parc Meadowbrook have worked to raise awareness to the plight of urban rivers both in the general public and with the different levels of government. There are also a number of daylighting projects under consideration along its course to improve flood management and water quality and maintain plant and animal habitats.

Keywords: St. Pierre River, Montreal history, Les Amis du Parc Meadowbrook, urban rivers, daylighting

Introduction

For over thirty years, the environmental group Les Amis du Parc Meadowbrook has been keeping a close eye on a small brook that crosses a disputed area in southwestern Montréal. This is the brook referred to in the name of the 57-hectare golf course called Meadowbrook Golf Club, which owners have been trying to develop for the last thirty years http://lesamisdemeadowbrook.org/development/the-st-pierre-river/.

Figure 1. The St. Pierre River in 1834. Source: Carte de l'ile de Montréal, 1834, by A. Jobin, BAnQ http://numerique.banq.qc.ca/patrimoine/details/52327/2243990?docsearchtext=ile%20de%20Montreal%201834

A rich history

There is much more, however, to this mere 200-m long brook. It is, in fact, one of the few visible sections of a river that used to flow from the foot of Mount Royal–a defining feature of the Montréal landscape–all the way to the St. Lawrence River. The St. Pierre River, as it is called, was both a witness to and a factor in the development of the city.

The river was named after Baron Pierre Chevrier de Fancamp, a nobleman from Picardie, France. He was a founding member of the Société de Notre-Dame, which financed the colonization of Montréal (Gilles, 2009).

The river's source may have been on the west side of Mount Royal; it then ran west before taking a sharp turn east in Lachine, where a fur-trading post was established in the second half of the 17th century. The river then formed a shallow lake known as Lac Saint-Pierre or Lac-à-la-Loutre (now the site of the Turcot highway exchange), which dried up during work on the Lachine Canal in the 19th century https://www.pc.gc.ca/en/lhn-nhs/qc/canallachine. The river finally reached the St. Lawrence in the Saint-Gabriel domain of the Notre-Dame Congregation, new home of the filles du roy sent to populate New France https://www.maisonsaintgabriel.ca/.

The St. Pierre River made it possible to cross the city from east to west without navigating the tumultuous rapids of the St. Lawrence River. To First Nations before the arrival of French colonizers, it was at once a means of transportation, a source of water for agricultural use and consumption, as and a hunting and fishing ground. French colonizers were quick to recognize its transportation potential and tried unsuccessfully to channel its waters and straighten its course; the technology of the time was not sufficiently sophisticated (Deudon 2012).

Under the French regime, three flour mills were constructed along the river; by building the St. Gabriel Canal on the domain of the same name, the seigneurs of Montréal, the Sulpicians, diverted the St. Pierre River to the Petite rivière, the site of the very first French establishment in Montréal founded by Paul de Chomedey Sieur de Maisonneuve and Jeanne Mance in 1642, where the Musée d'archéologie et d'histoire de Pointe-à-Callière now stands (Gilles, 2009) https://pacmusee.qc.ca/fr/.

The St. Pierre River played a role in Montréal's early industrialization, one linked to the fur trade. Tanneries (Transports Québec Synthèse de l'étude de potentiel archéologique) required a great deal of water for the treatment of pelts; the river was both a source of water and a means of disposing of industrial waste after processing. Other industries soon joined the tanneries, such as tallow factories and slaughterhouses, whose residue, compounded with waste from agriculture and housing, contributed to transforming the St. Pierre into an open-air sewer. Under growing pressure linked to public health, it met the same fate as many urban rivers in the 19th century (Gilles, 2009).

The construction of the Williams collector in 1832 was a first attempt at canalizing and burying the river. An engineering feat in its time, this 350-m collector is now part of the Musée d'archéologie et d'histoire de Pointe-à-Callière https://pacmusee.qc.ca/fr/expositions/detail/collecteur-de-memoires/. Throughout the 19th century and into the 20th, the river was progressively canalized into Montréal's sewer system, with major work being done in 1932 during the Great Depression with the construction of the St. Pierre collector https://fr.wikipedia.org/wiki/%C3%89gouts_de_Montr%C3%A9al . "Drainer" Andrew Emond has explored this maze of tunnels and published astonishing photos http://undermontreal.com/map/ . A woonerf recently created on the collector http://ville.montreal.qc.ca/pls/portal/docs/PAGE/ARROND_SOU_FR/MEDIA/DOCUMENTS/WOONERF_PANNEAU2_100.PDF reminds Montrealers of the presence of this invisible yet essential infrastructure. The case of the St. Pierre River is not unique: Prof. Valerie Mahaut of the Université de Montréal estimated that a mere 59 km of waterways remains in Montréal, where there may have been as many as 338 km in the 1850s https://journalmetro.com/actualites-outremont-mont-royal/1055893/environ-82-des-ruisseaux-disparus-a-montreal/.

New threats to the St. Pierre River

There remains, however, the 200-m section of the St. Pierre River snaking through the Meadowbrook golf course. The brook was at the heart of a recent court battle in which the owners of the property, real estate developers Meadowbrook Groupe Pacific, demanded that the City of Montréal stop polluting the river on their land.

The brook is fed by the Toe Blake rainwater collector that serves a number of residential areas in southwestern Montréal. As early as 2002, the City was aware of the poor quality of the water (Réseau de suivi du milieu aquatique, 2002). The City of Montréal did a thorough study of the collector in 2014 (Réseau de suivi du milieu

aquatique, 2014), in an effort to pinpoint the source of the pollution. It showed pollution levels of 34,000 fecal coliforms per 100 mL (normal levels should be around 200). It was determined that the City of Côte Saint-Luc and the town of Montreal West, which border Meadowbrook Golf Course, were in fact responsible. The pollution is caused by crossed connections in their jurisdictions, where residential sewers have been connected to the rainwater system instead of the sanitary installations. To date, Côte Saint-Luc has found only four crossed connections on its territory and Montreal West 13 https://montreal-west.ca/wp-content/uploads/2018/09/informer-october-2018-web.pdf, which it will repair on a priority basis as it rebuilds its underground infrastructure.
In its 2018 decision, the Superior Court (Cour Supérieure du Québec, 2018) gave the City of Montréal two years to correct the situation. In February 2020, the City of Montréal undertook to temporarily divert the Toe Blake collector during dry periods while the source of the pollution is investigated.

Methodology

With the help of another environmental group, the Société pour Vaincre la Pollution (SVP), Les Amis collected samples in October 2018 at the St. Pierre River on Meadowbrook and had them analyzed for pollutants. Results showed the presence of over 6,000 coliforms per 100 mL. SVP also used the results of the 2014 City of Montréal study of the Toe Blake collector to draw a map of the addresses in Côte Saint-Luc (167) and Montreal West (51) where crossed connections might be found. This map was shared with both municipalities. Les Amis and SVP planned to do a rhodamine test to show the problem but it was too late in the season to proceed. Les Amis were also present at city council and agglomeration meetings, pressing elected officials for answers.
To further educate the public to the plight of urban rivers, Les Amis communicated repeatedly (Scott, 2018) with media and posted articles on its web site http://lesamisdemeadowbrook.org/development/the-st-pierre-river/. The group also sponsored several showings of the film *Lost Rivers* by Montréal filmmaker Caroline Bacle and gave its copy of the film to Montréal's library network. Members of our group organized a bike ride along the historic course of the river https://www.facebook.com/pages/category/Community-Organization/Balade-de-la-Rivi%C3%A8re-st-Pierre-River-Ride-235288763669216/ and led activities during Jane's Walks held every year in honour of urban activist Jane Jacobs http://lesamisdemeadowbrook.org/waterways/following-the-st-pierre-river-of-yesteryear/. Les Amis have campaigned for a great many years to preserve Meadowbrook and have collaborated with landscape architect Catalyse urbaine on the production of a master plan for an Urban Nature Heritage Park Accessible to All https://docs.google.com/file/d/0B74sG8jw2ZKLUWN2QXloZF80SEE/edit.

Efforts to daylight the St. Pierre River

Some thirty rivers and brooks once flowed across the City of Montréal (Mahaut, 2016). There are increasing calls to daylight sections of these waterways in an effort to better manage surface water and alleviate the heat island effect. During flash floods, waste water often mixes with rain water and is sent directly to the St. Lawrence River without treatment. Municipal water collection systems are overwhelmed by the excess volume; the result is costly flooding.
The City of Montréal has looked into the feasibility of daylighting upstream sections of the St. Pierre River in the Turcot exchange project (Deschamps et al. 2013). The Quebec chapter of the World Wildlife Federation (WWF-Canada), through its project BLEUE MTL, is also looking into the feasibility of daylighting a few sections of the St. Pierre River in the Sud-ouest borough (WWF-Canada, 2018).
Other projects fall under the category of cultural restoration, where residents are reminded through different means of the past existence of a river. A bike and pedestrian pathway at the base of the Falaise Saint-Jacques (Turcot, 2018), a 4-km forested area that stretches along what used to be *lac Saint-Pîerre*, is soon to be completed, with marshes that will reconnect Montrealers with their history and geography. (The Falaise, part of the terrasse Sherbrooke (Transports Québec Synthèse de l'étude de potentiel archéologique) is an escarpment formed thousands of years ago by marine deposits in the Champlain Sea). Following public consultations, the Office de consultation publique de Montréal (OCPM) also submitted recommendations in the summer of 2019 for the creation of a nature park with water features, on land left over from the construction of the Turcot exchange. This new nature park would serve as a dramatic gateway to Montréal (Office de consultation publique de Montréal, 2019).

Discussion and Conclusion

As we submit this paper, the fate of Meadowbrook and its brook is still undecided: owners of the golf course have taken their suit against the City of Montréal to the Supreme Court of Canada. They also have a suit against the City of Côte Saint-Luc, ongoing since 2001.

Furthermore, it remains to be seen how the water level in the brook will be affected by the deviation of the Toe Blake collector and to what extent the pollution problem will be resolved. As for the daylighting proposals, they are just that: proposals. They do, however, have the potential to redefine the relations between residents and their waterways from an environmental, biological and heritage point of view.

Acknowledgment

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ILISOS RIVER: UNCOVERING HISTORY

Christoforaki K.[1]

[1]*National Technical University of Athens, Athens, Greece,*
ka.christof@gmail.com, kchristoforaki@arch.ntua.gr

Abstract

Due to its special and rather peculiar history, the city of Athens is characterized by a dense and often unplanned urban fabric. This led to the formation of a capital with fragmental public spaces that have little to no connection to each other. What is more, these few open spaces are unevenly distributed within the city and thus, cannot affect a wide range of neighbourhoods. The planning strategy for the modern European cities (UN, 2015) imposes the creation of a sustainable development plan that will benefit capitals suffering from low quality urban space. As part of this strategy, connecting green spaces by creating blue or green passages within the urban fabric results to a network of open spaces that multiply the positive impact to the city. Athens can work towards this direction by re-evaluating past planning strategies.

This paper presents the proposal of uncovering part of Ilisos river, in order to create a 2-kilometre blue corridor. Ilisos is the historical river of Athens. It was mentioned in the works of Plato and used to be a place of significant interest for the ancient city of Athens. It run in front of Kallimarmaro Stadium near the Olympion. During the 1950s the river was covered and replaced by a six-lane boulevard. The vision of the proposal was to create a passage alongside the historical riverbed. The passage would be an extension of the existing Athenian Great Walk, which connects historical monuments in the city centre. It would run between Kallimarmaro Staduim and the new Museum of Modern Art, creating a linear green corridor that promotes the principles of sustainable mobility, while connecting places of cultural significance.

Keywords: Ilisos river, blue corridors, uncovering river, sustainable mobility.

Introduction

To open the discussion on reversing previous river covering infrastructures, we need to highlight how the city is going to benefit by creating blue and green passages. In terms of sustainable urban mobility, creating networks of green open spaces can multiply the positive effect on the urban fabric. This means creating routs within the city that benefit pedestrians or non-engine operated vehicles, while enabling an increase of the users of the public space. The city of Athens is characterized by a dense and often unplanned urban fabric, with few and unevenly distributed green spaces. The city owes this characteristic to its special and rather peculiar history of land ownership, that early in its history made clear how challenging the implementation of a strategic city planning would be. Nevertheless, Athens is one of the European Metropolis that are lucky enough to have a long coastline, as Attica seafront is over 45 kilometres. Unfortunately, the seafront remains rather disconnected from the main city. The city centre is only 8 kilometres away from the seafront and has not yet managed to take advantage of this potential. Athens needs to find a way to create passages and roots and connect and exploit the viable parts and good aspects of the city. Networking may be the key to address an issue that is long established. Reversing past planning strategies and infrastructure in order to implement user friendly and eco-friendly strategies takes an open mind in town planning, but the European experience provides us with many similar and successful examples. In the case of Athens, even a small river like Ilisos can serve as an opportunity towards the creation of an open-spaces network that will instantly upgrade the living conditions.

The historical River of Ilisos

Ilisos river is one of the three rivers flowing in Attica since ancient Athens, along with Kifissos and Eridanus. The latter is probably a tributary of Ilissos and its traces have now been lost. Ilissos was located outside the city walls.

It started its route from Ymittos, passed in front of Arditos hill and in met Kifissos river somewhere near Moschato. From there on, the two rivers continued their course as one, to reach Faliro bay. (Fig.1) Not much water run in Ilisos and the river was almost dry the summer months. However, during Winter time it often flooded the area near Eleonas, creating a marsh that retained small amount of water throughout the year.
The river used to be a place of significant interest for the ancient city of Athens. We are informed about the image of the area in antiquity by descriptions written mainly by Pausanias but also by Plato. Pausanias describes the sights of the area with reference to statues and the landscape, while Plato, placing the dialogue of Socrates with Phaedrus on the banks of the river, captures the spiritual and philosophical dimension that derives from the natural formation of the small hill near the riverbank. The character of the wider area of the river, mainly as perceived by Kallimarmaro Stadium and the “frog island”, had a clear concentration of mental and physical activities in the area. Apart from the Stadium, the Lyceum of Aristotle, the High School of Kynosargos, the temple of Artemis and the Arch of Hadrian are located nearby, all of which created a cultural center in ancient Athens. (Travlos, 2005)

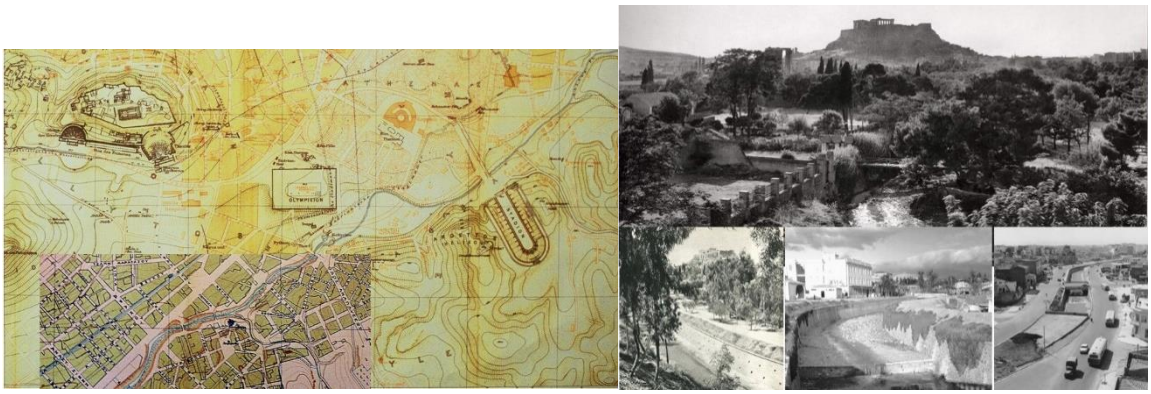

Figure 1. Left: Ilisos river in Ancient Athens , Right: Ilisos late 19th, early 20th century

Past Strategies

In the recent history, after the formation of the Greek state Athens did not extend near ilisos riverbed. However, the first new town plan by Cleanthes and Saubert attempt elaborate on the old city and to harmonize the newly introduced functions with the landscape. Kallimarmaro Stadium is connected to the city center by a – initially straight- road that would connect the palace directly to the Stadium. Also, a re-concentration of spiritual activities in the wider area of Ilisos is promoted initially, but the plans change rapidly, and this direction is lost (Biris, 2005). The development of the city takes place with a small to non-existent relation with the character of the area, while the preservation of memory lives on only in fragments through the preservation and promotion mostly of historical findings at point.
Due to the emerging housing needs, the city began expanding to its limits towards the end of the 19th century, and during the first two decades of the 20th. This led to illegal settlements near the riverbanks, or even in the riverbed. A whole refugee settlement at Zografou area was built on the riverbed. The river itself was downgraded and the living conditions near it were poor. People would through trash, debris, or sewage in the river. The area east of Ilisos slowly acquired a character of a poorer settlement, in contrast to the important landmarks on the west bank of the river. That made the decision of its covering rather easy as by that time, Ilisos was not that well perceived by the habitats of the nearby areas. Adding to the completely absent environmental awareness of the time, the frequent flooding of its riverbed, quickly resulted in the river being conceived as problematic and unhealthy.
In an attempt to reverse that image, it is initially decided to divert its riverbed in order to separate it from Kifissos. Soon after, the scenarios of its coverage begin. It is initially proposed to cover the riverbed at the part that starts from Zografou up to Kallimarmaro Stadium, with the intention of preserving the rest of the riverbed for historical reasons. The plan was to cover the river and turn it to a majestic boulevard, meeting the idea of modernization of the city as by that time, the car was already considered a sign of luxury. The river was gradually covered starting from the 1930s, but mainly during the 1950s (Biris, 2005) and is now flowing under Arditou street and King

Konstantinos avenue. Beneath it there are still traces of history. The historical bridge that Otto built during the 19th century that used to cross the river is well preserved under under the Arditou and Athanasiou Diakou junction (Fig.2), where cars literally run over it every day without any optical or physical connection to it.

Figure 2. Left: Bridge of Otto, Right: Pipes under it

The Proposal

The restoration Plan

After almost 70 years, in 2018, the concrete slab that covered Ilisos demanded repairing. Due to the problem that came up, the tram line that operated on top of the covered riverbed had to be aborted. At that point, the discussion of the uncovering of the river became relevant. The concrete slab had to be repaired using a reasonable amount of money on an infrastructure strategy from which Europe has already moved past. Climate change adaptation demands respect to the environment and inclusion of such aspects of the natural terrain, into the city fabric. Such a strategy will prevent future emergency situations caused by extreme weather conditions and also, create an upgraded living environment for the city users.

The discussion resulted in a proposal that included uncovering part of Ilisos river. The main strategy of the proposal was to create a passage connecting Kallimarmaro Stadium and the new Modern History Museum of Athens on Syggrou Avenue. By that time, apart from the out of operation tram line, the museum had no connection to the city centre. The proposal included the creation of a green passage of almost 2kilometers, that would link the two cultural poles of the city centre, while promoting the principles of sustainable mobility and climate change adaptation. The passage would run next to the uncovered riverbed and would be designed to support pedestrian users and bikers. Keeping in mind that Ilisos river is only a stream with reduced to no amount of water during summertime, only a small part of the existing avenue that runs above it would have to be removed. The plan was to remove only one car lane per direction, a reduction that does not seem to affect traffic as, the reduced lane would in fact be the removed tram line. The starting point of the passage was proposed to be at Arditou Street, giving the chance to bring to light the historical bridge of Otto.

The prediction for the tram line was to be redirected to Syntagma via Syggrou Av instead of Kallirois str. The redirection was in fact the rout originally planned, prior the 2004 Olympics. This would also make possible the prediction of a 4th tram line, and a bike lane that would continue on Syggroy avenue and reach the coastline at Faliro, as well as the Stavros Niarhos Foundadion, the Library and the new Opera. The connection of this pole of high cultural significance by transportation has been an issue ever since the operation of the Complex. Up to date, the most convenient way to reach the complex is by private car.

Last but not least, part of the proposal was organising a constant open dialogue with actual users of the city, to ensure that all needs are met. Besides online information, the project would be subjected to on-spot discussion prior its final approval.

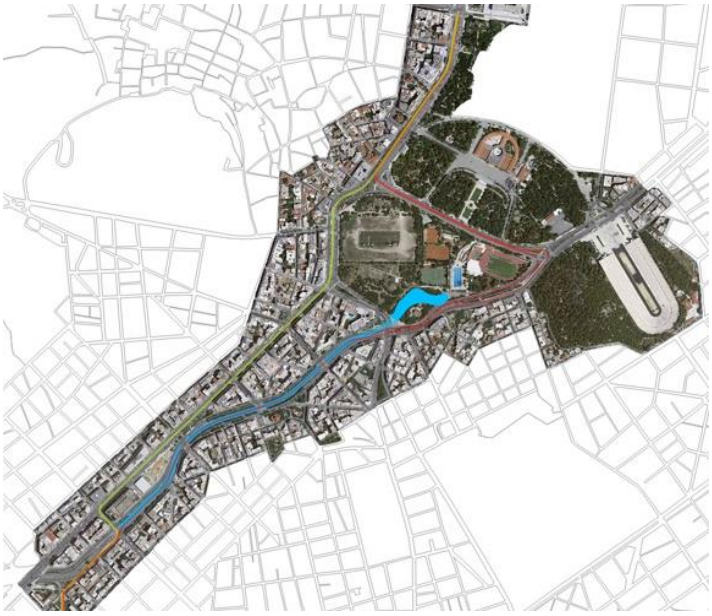

Figure 3. Proposal for Ilisos river, source: Athens Anaplasis SA Archive

Connection to the strategy

The idea of connecting places of significant interest using green passages was initially promoted by public company EAXA (Connection of Archeological Places of Athens), prior the 2004 Olympic Games of Athens. The Athens Great Walk of 2004 connected historical places of interest in the city center. It was a passage that connected the Olympion, Andrianou Arch, Theater of Herodus and Dionysous, Thision, Kerameikos ancient cemetery, leading up to the rock of Acropolis. The Great Walks' final part was designed to stop at Kallimarmaro Staduim via Olgas street which was planned to turn into a pedestrian road. However, that last part was not completed. The idea of Ilisos river passage was to connect it with the already existing Great Walk strategy. Olgas street reaches Kallimarmaro Stadium at the point where the proposed passage was planned to begin. This would lead to an extension of the original great walk that then could even reach the coastline via Syggrou Av., while linking places of cultural significance.

The practice of networking and creating bicycle routs that promote sustainable mobility is also supported by the Strategic Plan of Athens, (ΡΣΑ, 2014). The strategy highlights the importance of a wide network of bicycle lanes and railroad means of transportation, indicating Syggrou Av. as one of the potential axes to be considered.

In addition to the above, the European Agenda for cities, "EU Strategy on adaptation to climate change" urges to the redirection of past polices. The EU implementation of the Adaptation Strategy is based on eight actions. The first action focuses on the encouragement of all Member States to turn to comprehensive adaptation strategies, while the seventh action highlights the need for more resilient infrastructure (EU, 2013). The strategy also includes actions to support both financially and administratively, all members of the EU, on the implementation of infrastructure aiming to climate change adaptation.

Evaluation of the Plan

An important part of the planning process is the evaluation of the proposed strategy. The positive impact of the green passages in the city on the climate and image upgrade, as well as the revival of the city itself are non-negotiable. Enabling city users to safely walk in the city while experiencing the aspects of interest the city has to offer, brings people closer to the place they live in. Also, connecting open spaces results in the increase of the impact they have in the urban fabric, as a strong network is created gradually. In addition to the above, including actual users to the planning process increases awareness regarding use and protection of urban space, as well as provides a successful and targeted plan and uninterrupted implementation. A plan of such scale must be openly promoted and widely discussed with the public opinion.

However, while the positive impact of the proposal in the city is evident, we need to examine potential weaknesses. This proposal demands a long-term plan, and the cooperation of multiple public authorities. Past experience has

shown that Greece faces peculiar administrative difficulties and malfunctions as well as an, often, complex institutional framework. These difficulties could throw off a project of such extend and need to be addressed prior the implementation of the plan.
Another important issue is the funding of the project. Uncovering a two kilometers part of the river, regenerating the historical bridge, creating a bicycle lane and a green passage and also, in the future, adding a fourth tram line to connect the city to the costal front, costs multiple times the amount of just repairing the failing concrete slab. However, all the interventions serve the principles of climate change adaptation and sustainable mobility and thus can be considered a great investment for the city. In addition to that, European funding towards this direction is constant and, if proper action is taken, an infrastructure project of such extend could even be fully supported by the EU.
Last but not least, the apparent problem of water flow needs to be addressed. The stream may be dry for most of the Summer and this could create unhealthy conditions near the riverbed. The proposal should include a study that promotes alternative solutions for suppling water in the stream, considering even rainwater collection and redirection to the stream when needed.

Conclusion

The proposal aimed to open a discussion on using alternative methods to address issues that come up due to past practices, while creating an opportunity of networking and promoting both places of cultural significance and green open spaces in the city. Reversing past strategies might be quite optimistic, but Seoul set an excellent example of managing its river, when facing the same problem with the failing concrete slab that was covering it.
Green and blue infrastructure can be used to link distant but green urban spaces and thus multiplies its affect in the dense city. As shown above, creating a network can also ultimately link the city with the seafront and the Athenian riviera and its potential. In addition to that, creation of safe passages may serve as a chance of rehabilitation for areas or potential free urban space that was previously neglected or misused.
Athens, recovering from a long-term economic crisis that led to urban space neglection, can benefit from such strategies as, this planning strategy promotes a both functional and aesthetic upgrade of the public space in general. For Athens, this kind of integrated planning can also serve as an opportunity to promote the rich historical and cultural character of the area.
This way of addressing the urban space also promotes sustainable mobility, and climate change adaptation, and as a result helps the city create a high-quality living space and move towards the European goals for urban space development. Nevertheless, past experience has shown that for Athens, and Greece in general, implementing such large scale projects may be challenging in terms of project management or administrative functioning and it is as important to resolve those issues, in order to achieve upgrade of the urban space.

Acknowledgements

The proposal presented above was an idea formed by the public company Athens Anaplasis SA in 2018. The CEO of the company, Nikos Belavilas put together a task force team in order to promote the proposal and speed up the bureaucracy the complex legislation system causes. The task force included representatives of all the stake holders who had to meet in a regular basis to oversee the project. In addition to that, a wide circle of public consultation was planned, to include the city users in the planning process. The idea was abandoned after 2019.

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WATER VALUER: PARTICIPATORY ASSESSMENT OF RIVERINE ECOSYSTEM SERVICES FOR SUSTAINABLE WATER MANAGEMENT IN THE ARNO BASIN

Castelli G.[1], Pacetti T. [2], Bresci E.[1], Caporali E. [2]

[1] *Department of Agriculture, Food, Environment and Forestry (DAGRI), Università degli Studi di Firenze, Firenze, Italy, giulio.castelli@unifi.it, elena.bresci@unifi.it*
[2] *Department of Civil and Environmental Engineering (DICEA), Università degli Studi di Firenze, Firenze, Italy, tommaso.pacetti@unifi.it, enrica.caporali@unifi.it*

Abstract

Water-related Ecosystem Services (WES), defined as the multiple benefits that society can obtain from water or water-related ecosystems, represent a useful perspective to look at the interrelation between biosphere and anthroposphere in a river environment. Aiming at exploring the ecosystem-water-society nexus to support watershed management through the participatory evaluation of WES, the study considers the specific case of Figline and Incisa Valdarno municipality (Tuscany Region, Italy). The territory, part of the Arno watershed, is situated in an area where water has a strong socio-cultural and economic relevance for the citizens. Starting from the biophysical assessment of the study area, focus groups were organized to allow the participatory evaluation of WES, targeting mainly low impact stakeholders that have often little voice in the management process. Results show that the proposed approach allowed WES mapping and the identification of valuable WES characterised by a critical status. This further allowed the analysis of multiple scenarios and the identification of a shared river management strategy, jointly with local authorities and water management experts. Our analysis demonstrates the potential of WES concept as a suitable common framework for developing participatory processes over integrated water resources management. The study was carried out being fully inserted in an actual legal framework, since it was organised and funded in line with the Tuscany Region Law for Public Participation (L.R.46/2013). The proposed participatory approach can promote the involvement of all interested parties in Water Framework Directive implementation (Art 14) and foster a wider public participation in building river management plans.

Keywords: water resources management, ecosystem services, participatory approach, Water Framework Directive, river basin plan.

Introduction

The concept of Ecosystem Services (ES) represent a useful tool to explore and assess the complexity of natural resources management issues. ES are defined as the conditions and processes through which ecosystems sustain and support human life (MEA, 2005). Water-related Ecosystem Services (WES) are, specifically, the multiple benefits produced by water-related ecosystems (Duku et al., 2015) and therefore the most suitable for river basin management (Brauman et al., 2007). They can be categorized into four classes: supporting WES such as the support of aquatic habitats; provisioning WES, including water supply for the different types of production and for human consumption; regulating WES such as sediment and flow regulation; cultural WES that are related to the provision of cultural, religious, educational and touristic values.

In a watershed, terrestrial ecosystems can affect the attributes of the water (e.g. quantity, quality, spatial and temporal variability) that flows through. WES thus constitute an overlap of the biosphere and the anthroposphere (Spangenberg et al., 2014): spatiotemporal water availability and the presence of recipients (society needs) determine the passage from an ecohydrological process to a WES.

Society, in fact, acts as a driver for the transformation of the water-land system, also reacting with adaptation to its evolution. Due to this, on one hand, it is vital to model and carefully evaluate the human-induced pressured and modification to ecosystems such as human-induced land use change. This latter one impacts the green/blue water partition, strongly influencing the capacity of the territory to provide services (e.g. sediment and flow

regulation, water supply) and determining different kind of risks (hydrogeological risk, water scarcity risk, etc.). On the other hand, it is extremely important to analyse which are the human perceptions of the surrounding environment, in order to highlight the extents to which local citizenship is aware of the WES utilized and their value. Mixing these two perspectives can open the road to a better understanding of the importance of the ecohydrological processes that support WES (Everard et al., 2009).
With these premises, the objectives of this pilot study are (1) to realize an assessment of WES provided by water and land use setting in the territory of Figline and Incisa Valdarno (Figline e Incisa Valdarno) Municipality (FIV), within the Arno river basin in central Italy, based on GIS and participatory mapping analysis; (2) to carry out an analysis of the society perception of the value of water resources in the territory by utilizing a WES framework; and (3) to develop a standard framework for the valuation of such WES by integrating the results of objectives (1) and (2). The present research was realized within the "WaterValues" Project, financed by the Tuscany Region (Italy) in the framework of the Regional Law for Participation 46/2013. This approach aims to provide a sound basis for facilitating a participatory watershed planning process (within the EU Water Framework directive 2000/60/EC – EU WFD) where the instances of population are combined with the expert analysis.

Methodology

The study area included FIV municipality, Tuscany Region, Italy. FIV falls within the Arno river basin, with a rugged territory of 98 km^2 that include four main small left-bank tributaries (Figure 1).

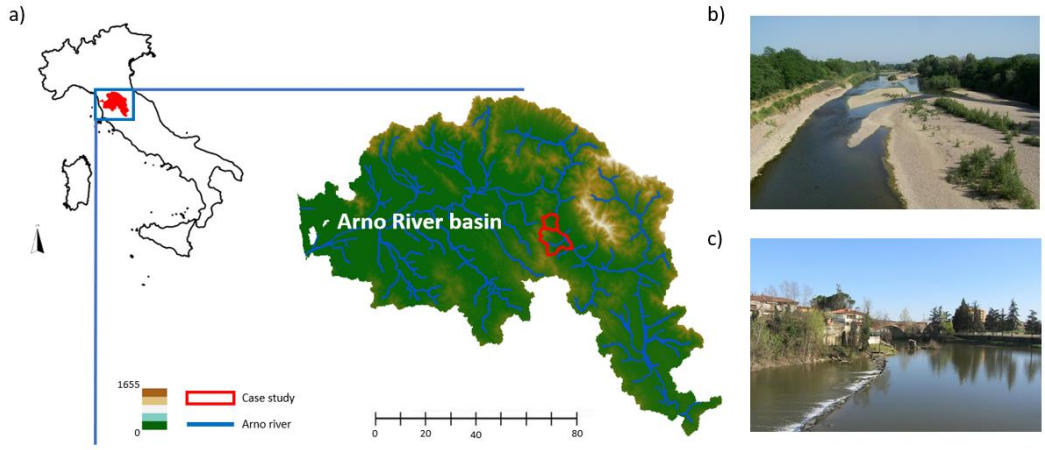

Figure 1. a) The entire Arno river basin with highlighted the municipality of Figline and Incisa Valdarno serving as research area; b) Arno river bars in Figline; c) Weir on Arno river in Incisa

In the area, Arno River and its tributaries, have a strong relevance for local population (e.g. fishing, gardening, recreation) and contribute to the touristic vocation of the area. Moreover, water represents a vital component of the economy of the area: besides the domestic consumption of the 23,000 inhabitants, water is withdrawn for industry and agriculture. At the same time, water can be a threat for the territory due to hydrological extremes. Recent droughts events caused water rationing during summer in FIV. On the other hand, the case study area is characterized by high hydraulic risk as indicated by several past flood events (e.g. the flood event of November 1966) that led to the realization of two retention areas realized upstream of the municipality (Galloway et al., 2017).
The methodology of the study (Figure 2) followed four main phases: (i) the biophysical assessment of the ecosystem capacity to provide WES; (ii) the analysis of the population and identification of stakeholder to be involved in the focus groups; (iii) the organization of focus group, which included: (iii-a) a first sub-phase of participatory identification of WES, (iii-b) a second sub-phase for their mapping in the area of study and (iii-c) a third one for the identification of valuable WES characterised by a critical status; (iv) the participatory scenarios analysis where the trade-offs between different management options are highlighted.

The first phase was carried out taking advantage of the analysis provided by the Northern Apennines River Basin Authority (Northern Apennines Water Management Plan 2015, 2nd cycle of EU WFD implementation), including both quantitative and qualitative indicators, which provided a fundamental basis of knowledge to determine the status of each water body in the area. The second phase was carried out through the analysis of population and associations living in the area of study, in order to identify a representative group of participants. This analysis led to the involvement of several association in the territory which were involved as "community champions" (Lindsay et al. 2019). The third phase was developed by organizing participatory meeting with the identified associations to produce an inventory of the perceived WES. To overcome the frequent problem of limited participation in plenary meetings, a tailor-made set of focus groups was organized with the different association at their own headquarters.
For each focus group, a list of all the WES perceived through participants discussion was elaborated. Then a participatory mapping activity was realised with the support of Google Earth as interactive digital mapping tool. Finally, each focus group evaluate the status of WES present in the municipality, on a 3-level ranking: "good", "poor" and "critical" status.

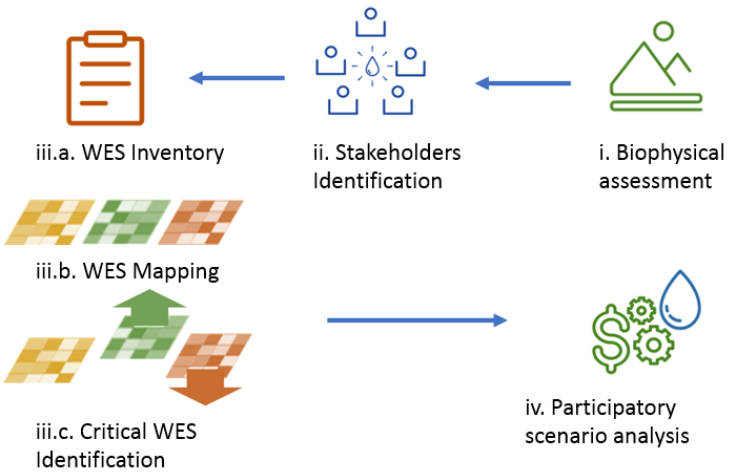

Figure 2. Graphical sketch describing the participatory process methodology

The fourth phase involved the citizens of FIV who already attended the focus groups in a discussion with selected water professionals and representatives of local institutions. This phase was organised as a final meeting where the results of different focus groups were discussed to reach a common evaluation of WES and of their status, and to provide potential strategies to improve the level water and land management in FIV.

Results

The selection of local associations to be involved in the process identified four main subjects: "Prociv - Protezione Civile", an associations of local civil protection servants; "Il Giardino", cultural association of retirees; Association "Soci Coop Figline", including local associated of Italian food cooperative Coop; and "Circolo fotografico Arno", a photographers club of FIV municipality with a specific interest on river Arno locations. The four focus groups realized with these associations allowed the definition of multiple WES lists, from which it was possible to derive interesting information regarding the different perception citizen have on WES. For each class of services (i.e. regulating, supporting, provisioning, cultural) a list of WES has been elaborated identifying also the area where the service itself was produced its perceived status. The associated mapping allowed also the localization of the main hotspots (i.e. areas of particular importance important for WES production or that have criticism - Figure 3). Supporting WES of "Water quality" and of "Support to water biodiversity", Cultural WES of "Fishing" and of "Cultural and Aesthetic value", all considered as produced by the River Arno main stream, were perceived in a "critical status" caused by the low water quality. Such characteristic was also confirmed by Northern Apennines Water Management Plan. This result indicates how citizenship is aware of the problem. In the fourth phase of the

process, Payment for Ecosystem Services (PES) scheme was indicated as suitable solution. The recreational WES localised in the riverside of Arno was also considered in a “critical status” due to the low level of maintenance. For this latter one, a River Basin Contract (RBC) framework was suggested as adequate tool to deal with this issue in the framework of the meeting realised in the fourth phase.

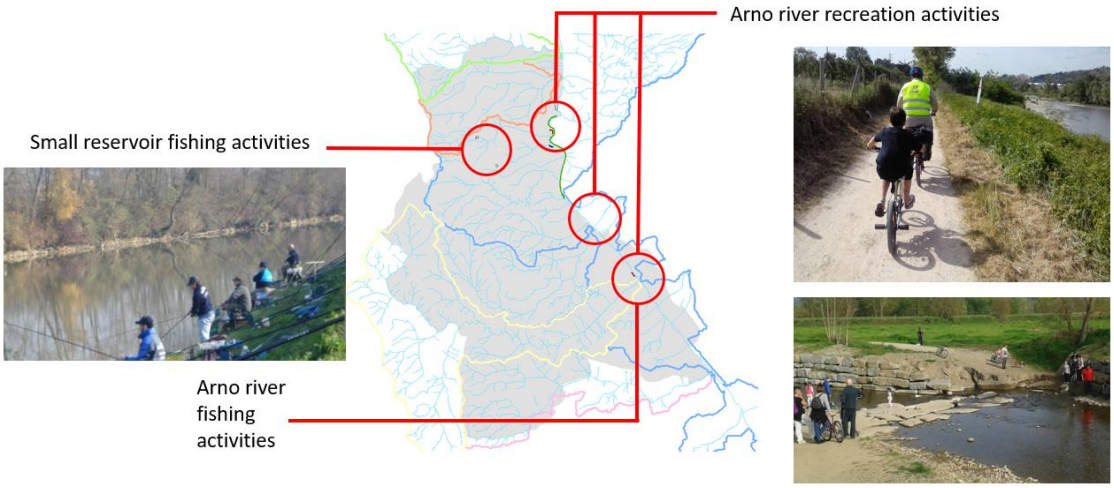

Figure 3. Cultural WES mapping. The Arno river is identified as the main hotspot due to the importance it has support recreation activities and the problem associated to its quality the limited the quantity of cultural WES provision. This figure is a graphic synthesis of the participatory mapping realized with a finer scale of details during the focus groups by digital mapping tools.

Discussion and conclusions

The present study highlighted how WES concept can facilitate an active dialogue between water management institutions and all the other stakeholders. The results of the participatory process allowed the identification of the main WES provided by the Arno river basin to FIV population, their participatory analysis, and the information of future policies for different management scenarios. The inclusive approach adopted in the present project enhanced the clear relationships between the citizens and the resources of the territory, highlighting their limits and potential. Water can be interpreted according to multiple scales of value: only understanding and seeking an ideal convergence between different scale of valuation can lead to an effective watershed management. Moreover, the present work served as a pilot implementation of the Regional Law for Participation 46/2013 of Tuscany Region, and at the same time as a support tool to the watershed development strategy of Arno River in integrating citizenship participation and ecosystem valuation, as prescribed by EU WFD.

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Environmental education and teacher training

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BIOPROFILES AND ENVIMOBILE: TWO PROJECTS TWO MODELS OF INNOVATIVE TEACHING OF ENVIRONMENTAL EDUCATION APPLIED TO WATER

Kovacova A.[1], López Giraldo JD. [2], Kahan J.[3] , Massetti L. [4]

[1]INAK, Slovakia, adriana@trochuinak.sk
[2]VITAXXI, Cabezo de Torres, Spain , jdlgiraldo@vitaxxi.com
[3]Strom Zivota/ Tree of life, Slovakia, jozef.kahan@stromzivota.sk
[4]Institute of Bioeconomy CNR, Sesto Fiorentino, Italy, luciano.massetti@ibe.cnr.it

Abstract

Bioprofiles (Implementation of practical environmental education in school) and Envimobile (Integration of mobile learning into environmental education fostering local communities development) are two projects, funded by Erasmus +Program, proposing innovative and engaging ways of teaching environmental education inside/outside the school Both projects targeted teachers of primary and secondary schools (age 10-15) and aimed to improve their competences in teaching environmental education through the implementation of training courses and provide teaching materials: practical lesson units implementing also CLIL, ICT games and other innovative materials. Lesson units were designed keeping in mind common constraints in school environment: e.g. lack of time, low cost and easy implementation.

Both projects were structured in three phases; training and development of teaching units, test in classroom, translation in national languages as Open Educational Resources (OER). Around 100 teachers were directly involved by the two projects by participating to five-days training courses and by developing, contributing to improve and test the lesson units developed in both projects. Seven main topics of environmental education were identified and one of them regarded WATER and any environmental aspect related to this global key topic. In Envimobile, more than fifty units (ten of them dealing with WATER topic) were developed following the three steps EAR methodology (Evocation, Appreciation and Reflection) and integrating CLIL and use of ICT. In Bioprofiles project, fourteen activities were developed. Each activity regards the study and monitoring of an indicator of environmental quality (two them deal with WATER topic) at local level Activities are structured according to a methodology that implies the assessment of the indicator at local through data collection and analysis, and fostering actions to raise awareness at community level and propose solutions to mitigate it. Both projects aimed to use environmental education as a framework to improve students active citizenship at personal level (Envimobile) and community level with connections with key social issues (Bioprofiles).

Keywords: environmental education, water pollution, ICT, outdoor lesson, project based learning, SDGs,

Introduction

This ongoing world crisis due to the coronavirus pandemic put the focus on science highlighting contrasting aspects. On one hand, science has been considered by governments, even if not always promptly, to make the right choices to contain the COVID19 pandemic, especially when it was accompanied by reliable information.on the other hand it has shown its difficulties in gaining the trust of citizens who can be more easily attracted to conspiracy theories and fake news (van Bavel et al., 2020). This underlines the importance that science is understandable by citizens as well as citizens are able to critically and consciously interpret science. The Council of of the European Union stated in (2016) that “the exponential growth of data, the availability of increasingly powerful digital technologies, the globalisation of the scientific community, as well as the increasing demand from society to address the societal challenges of our times, are the bases of an on-going transformation and opening up of science and research, referred to as ”open science” affecting the modus operandi of doing research and organising science”. Citizen science can make science more socially relevant, accelerate and enable production

of new scientific knowledge, increase public awareness about science and ownership of policy making, as well as increase the prevalence of evidence-based policy making (Warin and Delaney; 2020).
The engagement of citizens and civil society in research and innovation should be coupled with public outreach activities to generate and sustain public support for wide European social programmes. They should also seek to remove barriers and boost synergies between science, technology, culture and the arts to obtain a new quality of sustainable learning as well as support an inclusive approach to gender equality in research and education.
In this context, scientific and environmental education play a decisive and key role, and also schools are the ideal and fundamental playground before facing any social reality.
To be more effective, education should apply innovative and practical methodologies that engage students interest towards science (Pedaste et al., 2015) and show the linkage of their activity at school with concrete local and global issues of our changing society (Rickinson, 2001).
Bioprofiles and Envimobile are two ERASMUS+ project that try to respond to these needs by proposing methodologies that aim to deal with environmental topics and issues, being one of the most relevant The water, Where students playing a central role in all educational phases: learning the scientific method and selecting contents; and making a reflection on the importance and consequences on their personal life and their local and closed neighbourhood , plus ending on wider social ; actions for a change on both personal and community level.

Methodology

Bioprofiles (Implementation of practical environmental education in school) and Envimobile (Integration of mobile learning into environmental education fostering local communities development) are two projects, funded by Erasmus +Program (2014-2016), proposing innovative and engaging ways of teaching environmental education inside/outside the school Both projects targeted teachers of primary and secondary schools (age 10-15) and aimed to improve their competences in teaching environmental education through the implementation of training courses and provide teaching materials: practical lesson units implementing also CLIL, ICT games and other innovative materials. Lesson units were designed keeping in mind common constraints in school environment: e.g. lack of time, low cost and easy implementation.

Envimobile project

Envimobile (2014-2016), Integration of mobile learning into environmental education fostering local communities' development was a project funded in the framework of the ERAMSUS+ programme. Five partners active in the area of environmental and science education from four European Countries (Slovakia, Italy, Spain and Czech Republic) joined together to bring innovative activities into environmental education, integrated with the use of Information and Communication Technologies (ICT) and fostering educator's interest and participation of local people in communities' life. The project targeted primary and secondary school teachers of the participating countries and aimed to provide innovative and interdisciplinary teaching materials focused on environmental education, designed to be used for content and language integrated learning (CLIL) and strengthen key competencies in the use of ICT for teaching. These goals were achieved by providing three main outcomes: a training course, a series of pedagogical materials (activities) and a mobile application of interactive environmental questions and answers exercises. The core of the project is environmental education as a whole, that was divided in seven key themes air, water, biodiversity, energy, natural and cultural heritage, human environment and waste . Initially, a need analysis was performed through an international questionnaire in English language that was compiled by 106 teachers form the participating countries. This referenced need analysis aimed to rate the importance of each themes from teacher's perspective and to identify the relevant topics within each theme that would have been the base of content materials. All themes got high scores in terms of urgency of their integration in the school curricula and water pollution resulted one of the most needed (67%), being overcome only by waste theme (82%). In 5-point Likert Scale ((from 1=no need to solve, I do not consider this to be a problem until 5 =needs urgent solutions, it is a serious problem), water pollution was rated 5 by 46% respondents and 4 by 26% respondents (Tab. 1).

Table 1 – Percentage of interested teachers and number of themes for each topic.

Theme	Percentage	N. of topics
Waste	**82%**	**8**
Water pollution	**67%**	**8**
Air Pollution	**64%**	**7**
Biodiversity	**62:%**	**11**
Human Environment	**61%**	**7**
Natural and cultural heritage	**60%**	**7**
Energy	**53%**	**6**

Teachers rated also specific topics within each theme and proposed new ones. A total of 54 topics were identified, 8 regarding water pollution (e.g. Drinking water sources, Eutrophication, Groundwater pollution) The second pillar of the project is the EAR method that was developed during the project.

The EAR is a method of dealing in education with an environmental topics following three steps: **evocation** that raises the interest about the topic and find what students already know about it, **appreciation** that keeps them focused on the topic and stimulates the active participation to the lesson (experience learning) and **reflection** that helps them to be conscious of their personal implication of what they learnt. Each step of EAR can be implemented by applying different didactic approaches for engaging student interest (e.g. brainstorming, life poem, elevator pitch, Know-Want to know-Learnt or K-W-L method, amongst others).
Each topic was developed according to this method by 43 selected teachers which participated to a five days training course held in three countries Slovakia, Spain and Italy. Teachers as a part of the learning trip to know about the project, the structure of the content (themes and topics), the EAR method and the single didactic approaches. They were also trained to develop exercises (in the form of single select questions) regarding the seven environmental themes that would be the core of a question game for smartphone devices (ECOUp).

At the end of the course, each teacher selected a topic and developed a didactic unit structured according the EAR methodology related to it. Some teachers also proposed and implemented topics that were not included in the original list and that were considered relevant. Therefore, at the end of the project, 58 didactic units (10 regarding water pollution) were created (Kovacova et al. 2018) and translated in four languages (Slovak, Czech, English, Italian and Spanish).

Bioprofiles project

Bioprofiles (2018-2020), implementation of practical environmental education in school is a project funded by the ERASMUS+ programme, composed by 6 partners from five European countries: Slovakia, Spain, United Kingdom and Italy. The project aims to provide school teachers of students of age 10-15 with new educational materials and practical activities for promoting young active involvement on environmental issues classified in seven themes (the same of Envimobile). The projects materials were designed to engage students in the study of local environmental issues and in proposing solutions for their mitigations, thus developing both their scientific thinking and proactive behaviour by knowing more closely the living systems and environment in their surroundings, monitoring their quality and looking for pro-active proposals to enhance them. A five days training course was designed specifically for supporting teachers' professional development and skills in active use and implementation of environmental topics into teaching by providing innovative teaching materials and integrating practical environmental concepts into teaching process; delivering high quality teaching by adopting new pupil-centred methods of research-based learning; to increase teachers' and pupils' environmental awareness through monitoring of local environment and to reinforce the link between global issues and Sustainable Development Goals (SDGs). A total of 29 teachers from the participating countries attended the training course in Spain and Italy. During the course, 14 activities (2 for each theme) for studying indicators of local environmental quality were provided to teachers (http://www.teachinggreen.eu). Each indicator was structured as follows. problem definition at local level and methodology; data collection; analysis of the results; proposal and application of concrete action; and evaluation of its effectiveness. All the activities were designed to investigate issues that are commonly

widespread, have a local community relevance, can be done in a short time and low cost for implementation. Teachers selected two indicators and applied them in their classroom for testing their feasibility and effectiveness. Finally, the students coordinated by the teachers produced a report summarizing their experience: the followed procedure, the obtained results, their feelings, benefits and limitations.

Results

This section reports some examples of the implementation of activities of both project at school with a specific focus on those related to water.

Implementation of Envimobile at school

Teachers that participated to the training course translated one chosen topic in a didactic unit following the EAR methodology. As an example, the didactic unit about drinking water sources is shown in Fig. 1.

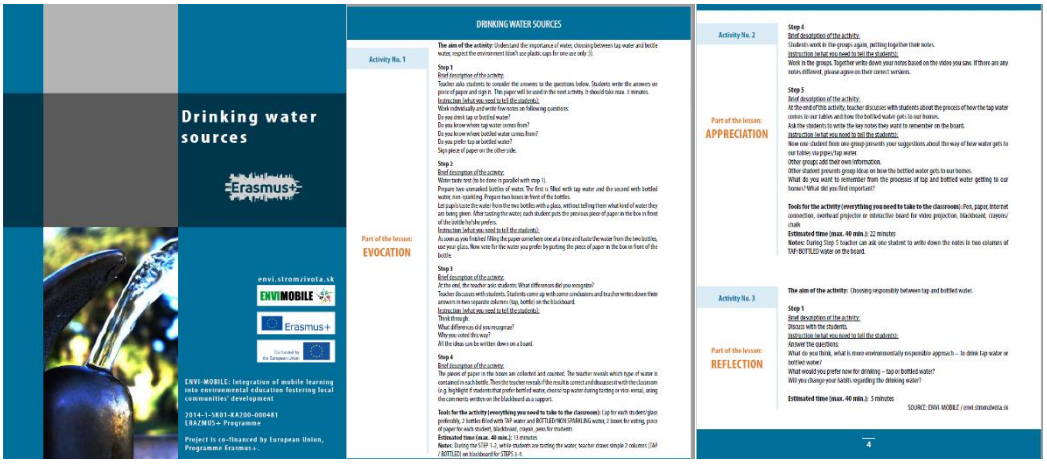

Figure 1. Drinking water sources didactic unit developed according to EAR (Evocation, Appreciation, Reflection)

The didactic unit is structured according to three phases, each phase is described in a very practical way. For each step a brief descriptions provided, as well as instructions to implement it, needed tools and estimated time. During the second year of the project, the activities were tested at school also by teachers that not participated to the development process (Massetti et al., 2016). Here we report an example produced by a primary school (Fig. 2).

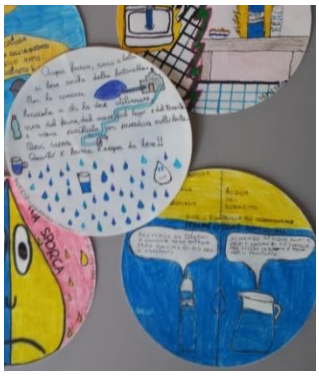

Figure 2. Drawing by students of the primary school Istituto Comprensivo del Galluzzo (FI) in 2016

They tested successfully the didactic unit about drinking water resources. The methodology enabled students to give space to their creativity and for the Appreciation phase they decided to present what they learnt in piece of paper in the shape of CD (Fig. 2), so that all the papers can be stored all together in a CD case.

Implementation of Bioprofiles at school

In this projects the activities on the environmental indicators were developed by the partnership and provided to the teachers at the end of the training course. Each indicator was described in a didactic unit that explains step by steps how to implement the methodology, indicates all the needed tools and provides predefined data collection sheets with formula embedded on them and examples on how to fill them (Fig. 3).

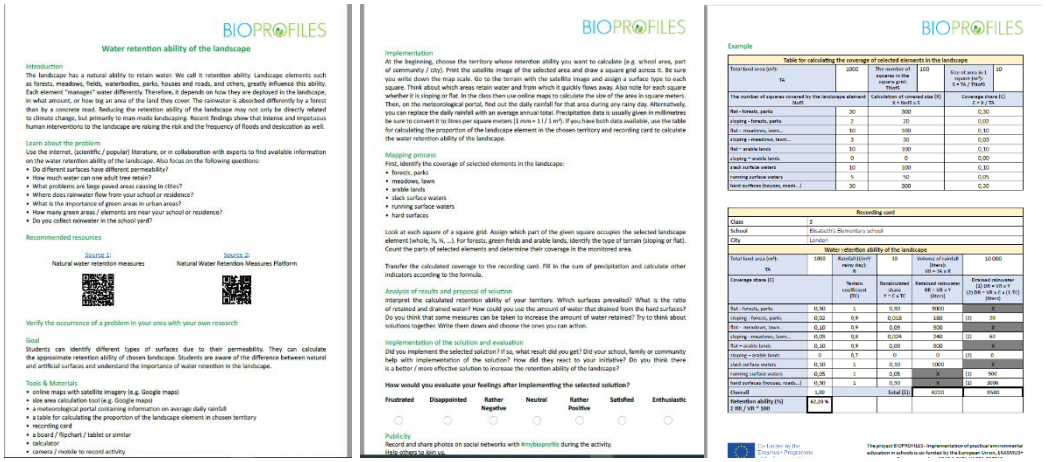

Figure 3. Activity of the indicator Water retention ability of the landscape

Teachers tested two indicators each in their classroom and at the end of the activity the students documented their experience in a power point presentation. For example, students made use of maps for classifying soil characteristics and worksheet to calculate water retention ability of the whole study area (Fig. 4). After implementation in classroom, all the presentation have been made available on the project website as reference and inspiration for other teachers who want to implement these activities.

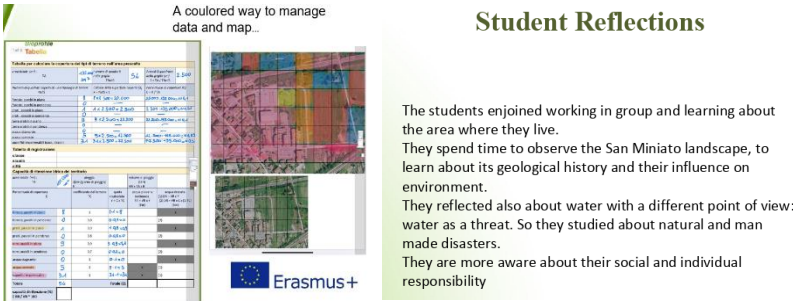

Figure 4. Two snapshot of a report about Water retention ability of the landscape made by the students of 2 Istituto Comprensivo "Franco Sacchetti" (ITALY) in 2019

Discussion and conclusions

In both projects educational activities regarding environmental education at school have been developed. On the one hand, the proposed methodologies favour practical activities where students can express themselves and interpret the proposed topics (Envimobile) and on the other hand they favour a scientific approach to the study of environmental quality indicators defined within the project (Bioprofiles). In both projects, the activities were developed taking into account the limits of application in the school environment: e.g. duration, cost of any additional equipment and integration with the school curriculum. In fact, each unit describes, step by step, the actions that the teacher must take to implement it and the necessary materials so that the teacher has available a ready-to-use lesson. This feature was greatly appreciated by teachers who can save time since they did not have to think about or build their own teaching materials from scratch. The activities also promote group work; active participation in the lesson; practical activities and data collection even outdoors; reflection on personal meaning and on their attitude towards the issues dealt with; and the proposal of actions, concrete changes both

on a personal level and within one's community. For instance, at Artero Public Primary School (Bullas, Spain) The teacher decided to work with water's indicator and they arrive to the following conclusions. (See fig 5)

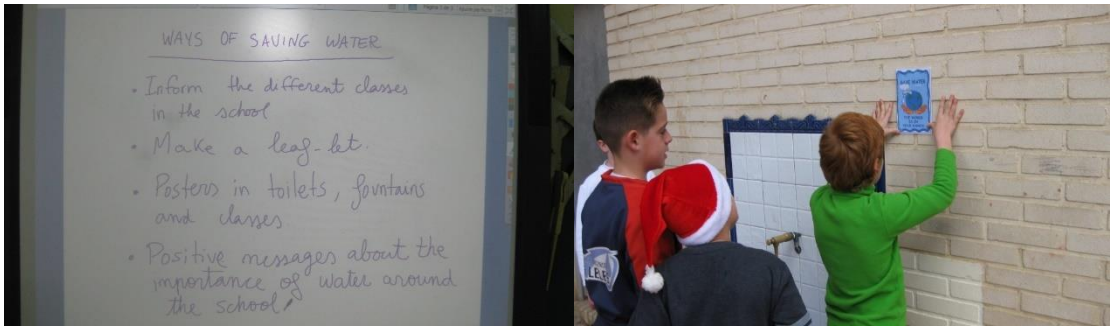

Figure 5. Artero Primary Public School Students (Bullas, Murcia, Spain) in action after reaching some conclusions working with Bioprofiles water indicator.(Photo: Ana Sánchez Courtesy)

And then, They decide to take action at the school. Making posters for each fountain on the play ground. Both teachers and students, including families were proud of their motivation and work.
In addition, the projects provided updated information on topics that are not yet fully developed in textbooks, such as the circular economy and zero waste (Waste) and the concept of geographical data through, for example, the mapping of territories to characterize the soil water retention (Water) or accessibility to green areas of a city (Human Environment).
Teachers that tested the materials gave a positive feedback, however some limitations were also pointed out. Time and curriculum constraint, and in some case, even confidence with topic and with the methodologies were the major difficulties pointed out by teachers, though their relevance seemed to vary among countries and even among teachers with different background. However, during the teacher training sessions their feedback was really positive while they were asked 65 questions (see example about one of the questions in Fig. 6).

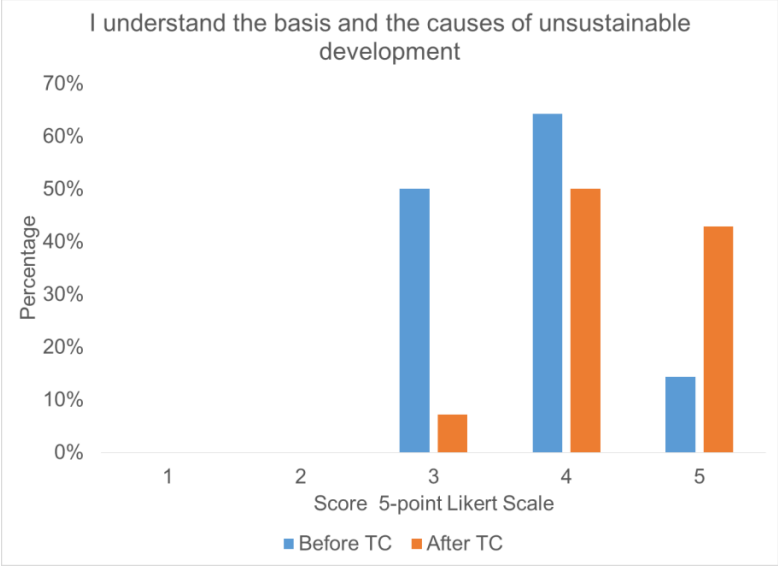

Figure 6. Percentage of responses according a 5 point Likert scale provided by teachers before and after the training course (TC)

Besides, when teachers were asked about Bioprofiles training, the responses were:
"*Pleased of having acquired different innovative methodologies ""*
"I am enthusiast about the topics that I've learned, the activities and the people that I've knew. I hope to achieve good results".

"I have learnt a lot, and I will use a lot of new knowledge in teaching process"
"I have new knowledge and experience how to work in environmental education

Additionally, we asked also the teacher in the course about their expectations and resolutions about their participation on this project and some of the answers were:
"Learn specific English unit, interaction and communication about approach and methodology learn unit and how do we can teach about skills for study living systems"
"I would like to improve my skills as a teacher, to learn new methods to teach my students, to create activities to use in my lessons which help pupils to understand the world, to have the opportunity to share experiences with other teacher from different countries and more"
"The students I work with live in an inner city suburban area that has it is own environmental problems. The students are generally from an average or below average socioeconomic background and the local environment does not always present as high on their priorities. I would like to develop a way of engaging students with their environmental surroundings"
"Learn new methods of teaching sustainability and gain new resources".
"A lot of inspirational materials for teaching"

In conclusion, these two projects provide more than 70 activities for practical environmental education at school (12 units about Water) that are available for all European teachers that want integrate hands-on activities, outdoor learning, STEM, learning outside the classroom (LOTC) promote proactive behaviours towards environmental issues, research methodology and real problem based projects in primary and secondary schools.

Acknowledgements

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DAYLIGHTING RIVERS
SCIENCE EDUCATION FOR CIVIC ECOLOGY

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USING SOCIAL NETWORKING SERVICE (SNS) FOR ENVIRONMENTAL EDUCATION: EXPERIENCES, CHALLENGES AND RECOMMENDATIONS

Zhang Z.[1], Huang X. [2]

[1]*University of Windsor, Windsor, Ontario, Canada, zuochen@uwindsor.ca*
[2]*University of Windsor, Windsor, Ontario, Canada, huang179@uwindsor.ca*

Abstract

Social networking service (SNS), also called social networking site, social media, or social networking software, such as Facebook, blog, WhatsApp, WeChat, Instagram, wiki, YouTube, and Twitter have users of various age groups from different walks of life around the globe. With the increasing affordability and availability of information and communication technologies (ICT), access to SNS is constantly on the rise, and as SNS can help to create communities of learning, a lot of research has documented its pedagogical values for a variety of disciplines in the education domain. Environmental education, which addresses environmental knowledge, environmental awareness, and pro-environmental behavior, is considered an important topic that is related to the discussion on environmental issues, and it has been an area that attracts the attention of a lot of researchers in recent years. It is suggested that besides school-based approaches, science education should also examine free-choice science learning environments, and SNS has played a significant role in this regard. Based on a systematic review of relevant literature published in academic journals in the past decade, this paper is designed to explore 1) pedagogical values of SNS in elementary, secondary, and tertiary education settings, 2) theoretical perspectives that are closely linked to the use of SNS for environmental education, and 3) projects carried out by using SNS to empower and enhance environmental education. In addition to a synthetic report of outcomes and challenges demonstrated in the existing literature, some recommendations are provided with the hope to assist interested colleagues to effectively take advantage of SNS as a venue for environmental education.

Keywords: Social networking service (SNS), environmental education

Introduction

Social networking service (SNS), also called social networking site, social networking media, social media, or social networking software, such as Facebook, blog, WhatsApp, WeChat, Instagram, wiki, and Twitter, is 'a web-based service that allows individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system' (boyd and Ellison 2007, 1). In the education domain, SNS can be used as a venue for educators to tailor a sharing of resources, posting personal thoughts and responding to questions that provide opportunities for sustained professional conversations around teaching and learning (Huber 2010), that involves a type of 'discussion brokering' where participants contribute to group discussions, but also engage in questioning and critiquing of thoughts that are being shared, for the main purpose of learning together (Grossman et al. 2001, 979). Environmental education, which addresses environmental knowledge, environmental awareness, and pro-environmental behavior, is considered an important topic that is related to the discussion on environmental issues, and it has been an area that attracts the attention of a lot of researchers in recent years. It is suggested that besides school-based approaches, science education should also examine free-choice science learning environments, and SNS has played a significant role in this regard.

Based on a systematic review of relevant literature published in academic journals in the past decade, this paper is designed to explore 1) pedagogical values of SNS in elementary, secondary, and tertiary education settings, 2)

theoretical perspectives that are closely linked to the use of SNS for environmental education, and 3) projects carried out by using SNS to empower and enhance environmental education. In addition to a synthetic report of outcomes and challenges demonstrated in the existing literature, some recommendations are provided with the hope to assist interested colleagues to effectively take advantage of SNS as a venue for environmental education.

Methodology

This paper is a systematic review of literature related to SNS and environmental education that were published in English academic journals. The search of the literature was mainly conducted using Google.ca, Google Scholar, and websites of some journals, and criteria for selection include 1) close relevance to topics such as pedagogical values of SNS in education settings, theoretical perspectives that are closely linked to the use of SNS for environmental education, projects carried out by using SNS to empower and enhance environmental education, and 2) articles that were published in the past decade. However, a few earlier publications were also included as they were deemed to have very influential factors to later research projects in the field.

Results

Pedagogical values of SNS in elementary, secondary, and tertiary education settings

Literature shows that SNS has pedagogical values for teaching and learning at different levels and subject areas, and an in-depth understanding of the relationship between the use of SNS and learning is that by using SNS, students are actually practicing the kinds of 21st-century skills they are expected to develop (Brindley 2012), which means that the use of SNS can not only benefit student learning in specific contexts, but the use itself can bring about educational outcomes. Among users of SNS, younger people are more actively engaged in the use of such spaces, which are deemed useful more for social than learning purposes. The study of Roblyer et al. (2010) on the use of SNS by college students and faculty found that 95% of students reported having a Facebook account while only 7% faculty did, but students and faculty shared the perception that the SNS was the least-commonly used technology for instructional purposes. And they suggested that even though their research participants mostly perceived Facebook as a tool for social rather than educational purposes, people's 'attitudes toward technologies tend to change over time' (138). Zhang, Tousignant and Xu (2012) encouraged their teacher candidates at a university in Canada to create blogs for their special education case study projects, and use wiki as a tool for peer editing. They observed that their teacher candidates used Facebook for professional development and networking as well as for social purposes. Glynn, Huge and Hoffman's (2012) study with Facebook users at a US university on factors related to news use on Facebook led the authors to believe that SNS 'will certainly play a large role in how citizens share information' (118). Wright (2010) argues that the use of SNS can help members to develop a sense of community, as members of such communities are usually people who are mostly like themselves (Yardi and Boyd 2010).

SNS is playing an important role in increasing environmental concern and environmental responsible behaviors in public (Krätzig and Warren-Kretzschmar 2014), as it can serve the purpose of making and organizing communities for climate change communication and education by widely raising awareness on environment issues (Koteyko, Nerlich, and Hellsten 2015; Newell and Dale 2015). Ebner et al. (2010) describe how this communication can foster 'process-oriented learning due to the fact that it can allow continuous and transparent communication' (93) which supports a social constructivist approach to learning. The learning process becomes transparent and as a result can benefit others who participate in the communications.

Through SNS, participants can access and share networks while fostering discussions and creating various forms of content (Kaplan and Haenlein 2010; Kietzmann et al. 2011; Ghali, Frayret, and Robert 2016), and thus are made aware of various environmental problems (Severo et al. 2019), and promote information for the awareness of various environmental problems (Kamaruddin et al. 2016; Ghali et al. 2016). Altin et al. (2014) and Mei et al. (2016) emphasize that environmental awareness is aligned with actions and attitudes, and Vergragt et al. (2016) stress the importance of active participation in activities concerning environmental issues. Chugh et al. (2016)

assert that due to the lack of environmental awareness, the degradation of natural resources for the sustainability of future generations has not got adequate attention. Hamid et al.'s (2017) literature review indicates that SNS had great potential for environmental awareness in higher education setting. Schroeder and Anantharaman (2017) suggest that individuals with environmental awareness are also socially responsible, because the more knowledge on environmental issues, the greater the sustainable attitude, as the exposure to information (videos, photos, texts) related to social responsibility and environmental sustainability positively influences in the formation of social awareness and respectively of the environmental awareness. Garay and Fonte (2012) and Boulouta and Pitelis (2014) emphasize that social responsibility is not necessarily only for altruism, but rather a combination of various reasons, with the emergence of environmental premises (Schroeder and Anantharaman 2017). Price and Lee (2013) assert that social networks and interpersonal communication are powerful instruments in changing attitudes toward science because people tend to change behaviors and opinions based on interactions and feedback from others.

Issa and Isaias (2016) reported that the use of the internet by generation Y (those who were born after 1981, see Strauss and Howe 1991) causes positive factors, such as collecting information, global and local awareness, and communicating and collaborating with peers and family members. However, Severo et al.'s (2018) study indicates that this generation has less motivation to improve the environment and society, as they have lower environmental and social awareness. Zahari and Esa (2016) point out that the consumers of Generation Y do not consider it important to adopt environmental practices, such as the use of renewable energies. Given that Generation Y seeks less information about environmental and social actions, there is a need for government agents and educational institutions to stimulate Generation Y to increase interest in socio-environmental issues (Severo et al. 2019).

Theoretical perspectives that are closely linked to the use of SNS for environmental education

Social learning theories (Greeno 2006) posit learning as located in contexts and relationships, or 'communities of practice' (Wenger 1998). They acknowledge the importance of individual and group learning within complex social organizations. Social learning theories also support the notion of *agency*, the idea that individuals and groups are both shaped by and actively shape their environments. Social learning theories suggest that learning addresses real-life problems and can occur in contexts that are not necessarily institutional, so they are particularly relevant to environmental education (Zepke 2005). Birdsall (2010) argues that action-taking for the environment is a key goal for environmental education, but the application of social learning theories to environmental education faces challenges, because learning *about* complex concepts or learning *to take action* in response to an issue in one context (e.g., online) may still have difficulty of meaningfully acting with or modifying that knowledge for new settings (e.g., offline) (Greeno 2006), meaning that 'learning that occurs in one kind of activity system can influence what one does in a different kind of system' (Greeno 2006, 80), 'but there are no guarantees the desired action will occur' (Robelia, Greenhow and Burton 2011, 555). The theory of free-choice learning (Falk, Storksdieck, and Dierking 2007) emphasizes a clear understanding of 'why, where, how, and with whom' learning occurs and suggests that free-choice learning can better motivate learners in an informal learning environment.

Projects carried out by using SNS to empower and enhance environmental education

Robelia et al. (2011) from the USA designed an open-source social networking application (Hot Dish) to 'distribute and discuss climate change news as well as engage users in pro-environmental action challenges' (553), which has a forum for users to discuss issues related to climate change and participate in Action Team challenges. Research data were collected from users via survey, focus group, and online discussions, which indicated that peer role modeling through interaction on the site motivated pro-environmental behaviors, because by participating in a community of like-minded users, many participants learned more about climate change and did more to limit its impact. The authors suggest that the key contribution of the Hot Dish application to informal environmental education is to offer free-choice learning about environmental issues and action strategies in a social context, as synergy was produced by 'combining up to date climate change knowledge with action strategies in an online social context' which convinced 'some citizens to increase their civic engagement and speak out for changes in public policy' (Robelia et al, 2011, 570-571).

Based on a survey of SNS users who were 18 to 30 years old from two universities in India, Kaur and Chahal (2018) concluded that 'Competitive power of social media helps in persuade users to bring change in attitude towards environmental issues than any other media type.' They suggest that users' involvement in SNS increases because of increased trust on social media contents, and this perceived trust attracts users to sharing their concerns pertaining to environmental issues. By involving in such sharing and discussion, they may get motivated to change their attitude towards environmental and sustainability issues.

Warner, Eames and Irving's (2014) study investigated four public school classes in New Zealand who volunteered to participate: a class of five-year-olds from one school, a class of 7-8 year olds from a second school, and two classes of 7-8 year olds from a third school, and their analysis of multiple qualitative data sets indicated that the blogs were well-received by teachers and students and did foster continued student engagement. The social media interaction only facilitated student action-taking if there was a shared philosophy between the environmental educator and the teacher with respect to the aims of the experiences and the value of action-taking. The importance of teacher attitudes in determining the value of social media is discussed as well as the benefit of dialogue among environmental educators and classroom teachers with respect to the philosophy of environmental learning experiences (83).

Tlebere, Scholtz and Calitz (2016) proposed a conceptual model called 'the Social Media for Environmental Awareness (SMENA)' for improving knowledge and thereby awareness of environmental issues, which was implemented at a South African university, and conducted activities of the environmental awareness campaign using a combination of social media website (SMENA website), Twitter and Facebook. The results showed that the campaign led to overall increased environmental knowledge, even though several students had resistance due to the fact that the use of SNS did not contribute to course credits.

Discussion and conclusions

While pedagogical values of SNS and its contribution to environmental education have been documented in numerous publications, there are many challenges for the implementation. For example, it could happen that students value and benefit from interaction on SNS, but teachers may not be as enthusiastic (Warner et al. 2014), as they may not have the knowledge, time or motivation to help their students turn their environmental learning into action-taking, or sustain it afterwards (Ballantyne and Packer 2011). Therefore, there should be training programs for teachers to learn how to integrate SNS in their environmental education, and teacher initiated follow-up activities are highly recommended and proper support should be provided for students to internalize the informal learning (Felix and Johnson 2013).

Yocco et al. (2011) maintain that in free-choice learning environments, the perceived ease of use of the technology plays a role, so deeper knowledge and attitudinal development that could lead to action depends on if the users are attracted to technology, and it should be kept in mind that not all users, especially some teachers, feel confident using different types of technologies that are beyond their comfort zone.

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AN EXPLORATION OF STEM PEDAGOGICAL APPLICATION FACILITATING ENVIRONMENTAL EDUCATION

Huang X. [1], Zhang Z. [2]

[1] *University of Windsor, Windsor, Ontario, Canada, huang179@uwindsor.ca*
[2] *University of Windsor, Windsor, Ontario, Canada, zuochen@uwindsor.ca*

Abstract

STEM (Science, Technology, Engineering and Mathematic) literacy is now considered as an essential outcome of education for all students (Capraro and Jones 2013) and identified as a key to cultivating creative and critical thinkers in current challenging environment as well as the responsible and capable members of the society with complexity. Therefore, the pedagogies in STEM education which are featured with integration of diverse disciplines as well as inquiry-based and project-based learning styles begin to attract educators' attention worldwide.

Environmental education is known as an indispensable part and a new approach of effective education, targeting at raising public environmental awareness and placing more value on substantiable development of environment. However, recent research showed that the environmental education focusing on the gain of hands-on experience and the understanding of concepts cannot achieve desired expectation due to the multi-dimension nature of the complexity of the real world. In this case, the effectiveness of integration of STEM pedagogy and environmental education has been increasingly emphasized and supported by the results and recommendations derived from recent research.

This article aims to review the related researches together with the interdisciplinary approach within the abovementioned two fields. Additionally, based on an outdoor project conducted by the first author in her civil engineering teaching, some inspiration can hopefully be provided to educators who are motivated by the ideas in both STEM and environmental education to explore and design innovative activities and curriculum, serving attitudinal and behavioral change of learners, enhancing the educational effectiveness and eventually raising young generation's environmental awareness.

Keywords: STEM pedagogy, environmental education, interdisciplinary approach

Introduction

STEM (Science, Technology, Engineering and Mathematics) education is considered as a key to cultivating creative and critical thinkers in current challenging environment as well as the responsible and capable members of the society with complexity. In this situation, the pedagogies in STEM education attract attention worldwide, concentrating on its integration with other disciplines as well as inquiry-based and problem-based learning.

Environmental education is now identified to be the most prominent instrument to influence human's behavior towards more environmentally sustainable patterns (Nicolae 2005). It helps cultivating responsible citizens to take care of our living surroundings, targeting at raising environmental awareness and focusing on the substantiable development in complicated context of society. However, recent research showed that the current environmental education mostly pays attention to the gaining of hands-on experience and the understanding of concepts describing environmental issues. This learning outcome cannot achieve the desired expectation of environmental education due to the multi-dimensions of the complexity in environment issues. In this case, Orr's asserts that all education should be environmental education (Orr 1992) to give more value on environmental education in our current society.

Nowadays, many countries continue to make reforms both in industry and education to address the needs of the world and they believe STEM is important to improve the quality of development both in individual and the society (Oyana et al. 2015). While the quality of the workforce is enhanced with STEM education, we should also pay

more attention to environmental literacy to help conserve natural resources (Kaya and Elaster 2019). Nowadays, the content of STEM is continuously widening and includes not only STEM but also the environment, economics, and medicine (Zollman 2012). Kaya and Elster explain the concepts of "E+STEM literacy", which is used to emphasis the importance of relationship between environmental and STEM literacy (2019). From the research conducted in the last decade, some educational practice can be found in integration of STEM and environmental education pedagogically.

This article aims to review the related research together with the interdisciplinary approach in the two fields to adopt effective guidance and design inclusive curriculum towards environmental education in elementary, secondary and post-secondary levels of education. Also, based on the personal teaching experience of the first author in civil engineering, some recommendations are provided to educators for exploring innovative activities to enhance learning outcomes and teaching effectiveness in environmental education.

Results

Importance of integration

While STEM education has been around for a long time, the importance of this concept has been emerged recently for legislators and educational administrators (White 2014). STEM education offers students the opportunity to realize their own potential, improve and strengthen self-efficacy, and supports them through their social and academic integration (Elster 2014). However, according to Kaya and Elster (2019), "addressing the needs for a high-quality STEM workforce in future industries might be based not only on STEM literacy but also on environmental literacy" (13). Mensah and Castro (2004) point out that environmental care is the "precondition for decent human life" (5). Therefore, the concept of "environment" should be integrated into the framework of STEM education to allow evolution to environment consciousness in classes and curricula (Kaya and Elaster 2019). Environmental literacy is an indispensable part in achieving sustainable goal not only for the welfare in current society but also for the benefits of future generation. In this case, we have the obligation to educate future generation as environmentally conscious individuals, taking into consideration the harms that science and technology have on the environment (Aydeniz 2017).

Inquiry-based learning

Inquiry-based learning is an approach that is directed by questions, problems, hypothesis or challenges and addressed by learners either individually or collaboratively. Inquiry-based instruction which clearly contains "surface, deep, and implicit structures as well as engages students to think and act like scientists" (Crippen and Archambault, 2012, 158) is considered a signature pedagogy in STEM educational process. Inquiry-based learning has been characterized as ranging from the traditional, structured and guided to the student directed (Bonnestetter 1998). As knowledge is pursued, unplanned but important learning territory is often uncovered (Kozak and Elliott 2014). Pretorius et al. (2016) additionally advocate that inquiry-based learning is "included in disciplines with a sustainability focus" (168). Due to its student-centered trait, inquiry-based learning can promote students to explore skills and knowledge applied to environment issues out of a personal willing and solve the real-world sustainability problems in a personal manner. In this case, learning becomes more authentic and makes it easier for retention (Barron and Darling-Hammond 2008).

Based on the findings of some environment research, the desired outcome of environmental education is considered as the changes in ABC (affection, behavior, and cognition) towards the environmental issues. Students should not only be introduced the concepts of natural resources and phenomenon which lack deep understanding and connection with the relationship between human activities and the impact on the environment. Because inquiry-based learning engages students in the investigative nature of science (Sandoval and Bell 2004), the process of inquiry which is usually associated with question-based learning provides learners an opportunity to immerge themselves in a context with complexity and help them establish the connection to what has been taught. According to the teaching project conducted by Small, students who take the inquiry instruction in environmental education become more "interrogative of solutions given" because the inquiry learning style appears to promote "deep, reflective thinking that results in changes in attitudes and behaviors" (2018, 17). Following this pedagogy, educators can assist students to think critically, ask questions, and collaborate with team members while probing

for answers regarding our environment. Therefore, the inquired-based learning is a beautiful accompaniment to environment education for cultivating responsible and capable citizens in protecting our planet and achieve the development of sustainability.

Interdisciplinary learning

Interdisciplinary learning is an integrated approach that brings together content and methods from more than one subject discipline, supporting connections that deepen understanding (Lake 1994). Because the natural overlap between the fields of science, technology, engineering and mathematics, the interdisciplinary approach is well suited in STEM education. Moreover, this approach is not only about teaching more content in these disciplines, but most importantly about structuring learning situations where students can draw on the knowledge, skills and ways of thinking from multiple dimensions and apply them in integrated contexts to solve problems, take real-world challenges and develop deep reflections to the environment everyone lives in. Capraro and Jones claim that “in the real world, solving social and environmental problems does not occur in isolated domains, but rather at boundaries of STEM fields” (2013, 53). Besides, research shows that the integration of mathematics and science also leads to student’s improvement in learning outcomes, increases their interests in subjects, and enhance the motivation of learners’ pursuit (Stinson et al. 2009).

Environmental education is based on the complexity of real-world system. The increasing environmental challenges have made people realize that human and nature are subject to common laws and the violation leads to ecological disasters. This cognition is closely linked with the development of environmental education from a single-subject understanding of specific natural mechanisms to a multi-dimensional comprehension upon all aspects of real-life (Orr 1992) which is integrated by economy, health, education, culture, political policy, and various social issues, such as justice and equality. Small identifies social culture, economics and environment as three essential components of educational sustainable development which is the content of environment education (2018). In this case, educational practice in environmental education should be supported by diverse attentions and cares from interdisciplinary approaches both inside and outside the classroom. Anyolo concludes that environmental education is a "collaboration of content and pedagogy that engages individuals in a study of the environment to encourage them to take positive actions towards it in an attempt to ensure sustainability for their societies” (2015, 2).

Kozak and Elliott (2014) believe that Environmental education draws on the dynamics of ecosystems to understand ecology. That means a systematical and growing view of learning is required to reflect on the process where interactions between different learning strategies are emphasized to better understand the power of interdisciplinary learning. Kozak and Elliott (2014) also advocate seven “dots” (6) interconnected (learning locally, integrated learning, act on learning, real-world connections, alternative perspectives, inquiry, and sharing responsibility) to achieve the shift from conventional environmental education to transformative one based on an interdisciplinary application. In other words, consequently, interdisciplinary learning in STEM provides learners a package of strategies, knowledge, skills gained from diverse areas, facilitating them to adopt multiple methods to solve problems and address challenges in environment with real-world complexity.

A project-based learning (PBL) practice at a civil engineering college

In order to provide our young people with necessary skills in 21st century and engage them in the challenges that we have been encountered in the current environment, linking Environmental Education with Science, Technology, Engineering and Math to gain the information of combination of disciplines is the curtail process. The first author used to be a teacher at a Chinese civil engineering college and during the process of her teaching, believing that pedagogies in STEM education can offer students opportunities to realize their own potential, improve and strengthen self-efficacy, and support them through their social and academic integration (Elster 2014), she tried to seek effective educational practice to illustrate how the pedagogies discussed above could be implemented in environmental education and enhance the learning effectiveness as a result. As Drake and Reid point out that integrated learning can be implemented through an inquiry model for deep, connected learning (2010), an outdoor activity was programmed including learning, communication, observation, and inquiry elements for civil engineering students to effectively engage themselves into the designing of bridges while authentically link their action and response to the environment around them.

In the preparation of designing a bridge, it is usually the most important task to investigate the construction site and the local environment conditions such as river, climate, community, culture, and animals. The learning project simulates the process that is necessary for professional designers in their real work. The project was organized in one village where there is a bridge construction work undergoing. The learning process was divided into five steps. First, teachers introduced the basic rules and potential challenges of the design work in classroom, associated with not only the technological but also environmental, economic and social aspects. Second, students were arranged to observe the bridge-building work under the guidance of the engineers working in the real program where students were welcomed to ask questions and encouraged to record their confusions for later discussion. Following that, there was a short seminar given by one manager from that construction company. During this seminar students were having a brief discussion to future explore their concerns and curiosities. Then students were required to walk into the village to communicate or interview the residents living in the local community to get their opinions about the construction. Most of environment-related issues were actually revealed during this part. Finally, after returning to classroom after the whole program, they were distributed into serval groups to discuss and collaborate for a conceptual bridge design based on their own observation and a presentation was required to assess their constructive ideas and to share their environment responsibilities.

This project succeeded in shifting traditional learning of civil engineering from isolated teacher-centered lessons to student-centered exploration and supported by real-world issue and hands-on practice. This project-based learning (PBL) can bridge discrete subjects into one program that address challenging questions and issues (Capraro and Jones 2013). The PBL promotes students to adopt a learning method that actively connects themselves with environment, effectively engage in the interaction among various disciplines and get self-motived to make a reasonable decision then solve problems in the real-world. Through this project, remarkable change of students' attitude can be noticed, especially in the local communication section where most students gained deep insight of the influence of construction work on human's daily life. For example, one student reported that from the communication with the villagers, they then realized that the sale of crops is the main source of the villagers' income, so he would like to revise the current concrete production site because the additive used in concrete would affect the soil condition of the river and consequently damage the crops. Apart from the meaningful skills and knowledge students obtained from the activity, their moral autonomy was also prompted dramatically. That means students can see themselves as agents of change, and they can make a difference in providing solutions for environmental problems that may be encountered in their work.

Although recent research shows that there have been various good practices and effective activities on environmental education globally, such innovative educational activities are still the exception and do not communicate with each other in some regions (Mareaki 2014). Therefore, the experience of the educational practice may provide educators with evidence and inspiration to contribute to both the environmental and the STEM education.

Conclusion

Environment education is becoming a major area of interest worldwide, and schools are increasingly being called upon to address global and local ecological concerns. However, most teachers have limited or no training in the knowledge and skills required to support their students' sense of connection to the natural world (Gillian 2010). This article hopes to illustrate what strategies can be adopted to help environmental education make a difference in students' awareness, behavior and cognition towards the sustainable development of current environment. The pedagogies applied in STEM can be considered as a way to generate new ideas and innovative solutions, supporting awareness-raising on environmental issues. The implications derived from the discussion may offer educators who commit themselves to environmental education the possibility to establish more ecologically-oriented education in all classrooms, thereby improving teaching and learning on environment as a result.

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ENHANCING AWARENESS TO FLOOD RISK THROUGH HANDS-ON MODELS AND SERIOUS GAMES

Pileggi T.[1], Megale G.[1], Pampaloni M.[1], Caporali E.[1]

[1]*University of Florence, Civil and Environmental Engineering Department – DICEA, Firenze, Italy,*
tiziana.pileggi@unifi.it, giulia.megale@stud.unifi.it, matteo.pampaloni@unifi.it, enrica.caporali@unifi.it

Abstract

The awareness of the population to the risk perception is an issue of growing importance in the mitigation of natural hazards. During a natural event, awareness of the dangers and self-protection behaviours can mitigate risk situations. In this context, the introduction of educational, informational, and public engagement tools that facilitate the understanding of the risk and improve its perception is certainly an effective way to contribute to mitigation.

The construction of physical models is traditionally a very good method to facilitate the understanding of complex phenomena, such as floods. Here, we propose the use of a physical model of flood scenario made with the famous LEGO bricks, to facilitate understanding and perception of hydraulic risk. Based on the LEGO model, recently a video game version has been preliminary designed. Using the Minecraft platform, produced by Microsoft, an actual serious game will be implemented on flood risk that has the city of Firenze as the reference scenario. The flood scenarios of the past and those resulting from the hydraulic models developed by the research group will be used to implement “role-playing games” related to the design of mitigation and hydraulic risk management measures.

In order to develop a method for the evaluation of effectiveness of the implemented serious game, a questionnaire was used, referring to some models available in literature. The elaborated questionnaire aims to provide a solid support to specific learning goals in terms of knowledge, skill and attitude, in order to assess the game quality and effectiveness as well as to contribute to its improvement and efficient adoption in practice.

Keywords: flood risk, awareness, hands-on model, serious games, evaluation, learning goals.

Introduction

Risk is a complex concept that is perceived by scientists and common people very differently. According to UNDRR (United Nations Office for Disaster Risk Reduction), risk is the probability of an outcome having a negative effect on people, systems or assets (UNDRR, 2020). Risk is typically described as being a function of the combined effects of hazards, the assets or people exposed to hazards and the vulnerability of those exposed elements.

The way in which the public perceive risk is heavily influenced by situational and cognitive factors. Risk perception can be considered as an individual’s interpretation or impression based on an under-standing of a particular threat that may potentially cause loss of life or property (Bradford et al. 2012).

Risk perception is defined by Slovic (2000) as the intuitive judgement of individuals and groups, of risks in the context of limited and uncertain information. Raaijmakers et al. (2008) specifies this definition and defines perception through the relationship of a specific set of risk characteristics: awareness, worry and preparedness.

In the context of flood risk, the awareness of it could be defined as knowledge or consciousness of the flood risk that an individual or a group of individuals is exposed to. Flood risk awareness increases when a society is threatened by a hazard, when information and education about the hazard is more widely available, and this information has implications for appropriate actions (King, 2000). However, a society or a community tends to forget about risks associated with infrequent events and as a result awareness may decline (Arthurton, 1998). Provision of information to, or education of the public usually increases awareness. Worry depends on the awareness of the frequency of occurrence of certain hazards. Depending on the expected severity of the consequences of the hazard individuals may worry about socio-economic effects of flooding such as economic

damage, damage to ecology or health, the disruption of family life and loss of life (Tapsell et al., 2002). Preparedness is both the capability of coping with a flood throughout the inundation period, and post-flood recovery capability and strategies (Van der Veen and Logtmeijer 2005; Messner F. et al., 2006). Preparedness can be described in several dimensions as social, technical, economic and institutional.
As part of the university's third mission, aimed at promoting the cultural, social and economic development of the territory in which it operates, the Spatial Data Laboratory of the Department of Civil and Environmental Engineering, starting from its technical-scientific peculiarities, it is very much engaged in communication activities with the public in the field of natural hazards, with particular reference to natural hazards and floods.
To increase awareness of the flood risk and to facilitate the understanding of the complex dynamics of floods, a series of educational and dissemination tools have been developed and are in progress which refer to hands-on models and serious games. These tools are also useful in counselling activities during meetings with students of study courses and high schools and in multidisciplinary collaboration between various thematic areas. In order to consider the effectiveness of these tools, an evaluation questionnaire was implemented, referring to some survey models and investigation existing in literature.

Tools for enhancing awareness to flood risk

The LEGO hands-on model

The first flood risk model through which the activity in the field of risk communication to the public was started is the hands-on LEGO model [Figure 1]. The LEGO model built at the Department of Civil and Environmental Engineering of the University of Florence, represents a portion of territory crossed by a river. It is equipped with a water storage tank and a pumping system, for the simulation of water flow and fluvial floods. The LEGO bricks model is positioned in a container of Plexiglas for water collection. The base of the model (length 120 cm and width 80 cm) is made up of three layers of wooden material, useful for representing engraved riverbeds, floodplains and adjacent areas of the existing river segment. The surface of the model is covered with LEGO plates, so that the geometry can be modified through the insertion of preassembled external LEGO elements such as bridges, buildings, vegetation and barriers, as well as elements dedicated to the mitigation of hydraulic risk such as detention basins, weirs, dams, levees, embankments and spillways. In addition, in the model have been included small elements that represent non-structural measures in the context of hydraulic risk, such as rain gauges, instruments for measuring flow rate as well as emergency reception areas for the population. All elements are labelled, and their main purpose is explained during the carried on simulations.
The bricks are a real building material, simple and above all modular, which allows a tangible representation of reality, able to effectively communicate the connection between theoretical and practical aspects of risk and suitable for immediate observation of the effects resulting from design choices, planning or behavioural. The model can be used to organize Serious Games aimed at increasing interest and active participation, as well as soliciting competition and encouraging good practices in the field of hydraulic risk.
The definition of the characteristics of the portion of territory to be represented has been defined starting from the proposals emerged within the assignment given to the students of the Hydraulic Risk course in the academic year 2017/2018, which, using the software LEGO Digital Designer, have made design hypotheses about the preparation of the model surface, representing an existing or fictitious urban area adjacent to the river and prone to flood risk. To counteract the flooding of these areas following the flooding of the rivers, students have prepared appropriate risk mitigation measures, planning various solutions and scenarios.

Figure 1. The LEGO hands-on model

A serious game in Minecraft

Minecraft with his “digital bricks” is probably the most popular game among young people because it is an immersive interactive game where players can express themselves, build three-dimensional objects and play with others in a vast open world environment. Lately, a new version of Minecraft has been released: Minecraft Education Edition, that is specifically designed for educational purposes and provides educators with a game-based learning platform that promotes creativity, collaboration, and problem-solving.

Exploiting the potential of Minecraft Education Edition, a mini-game is being implemented composed of different scenarios in which the players are thrown into a reproduction of the city of Florence during a flood event [Figure 2]. The final goal of the players is to recognise possible risk situations and learn how to avoid them, in this way they can succeed and “win”. The first scenario that has already been structured is set at the Uffizi Museum: a group of children within a visit to the museum with their teacher during a weather alert are requested by the museum’s attendant to move some objects from the depot to the ground floor before the depot is flooded. The players must recognise that they are in danger and to “win” the game they need to take the stairs and go on the second floor, away from the flood.

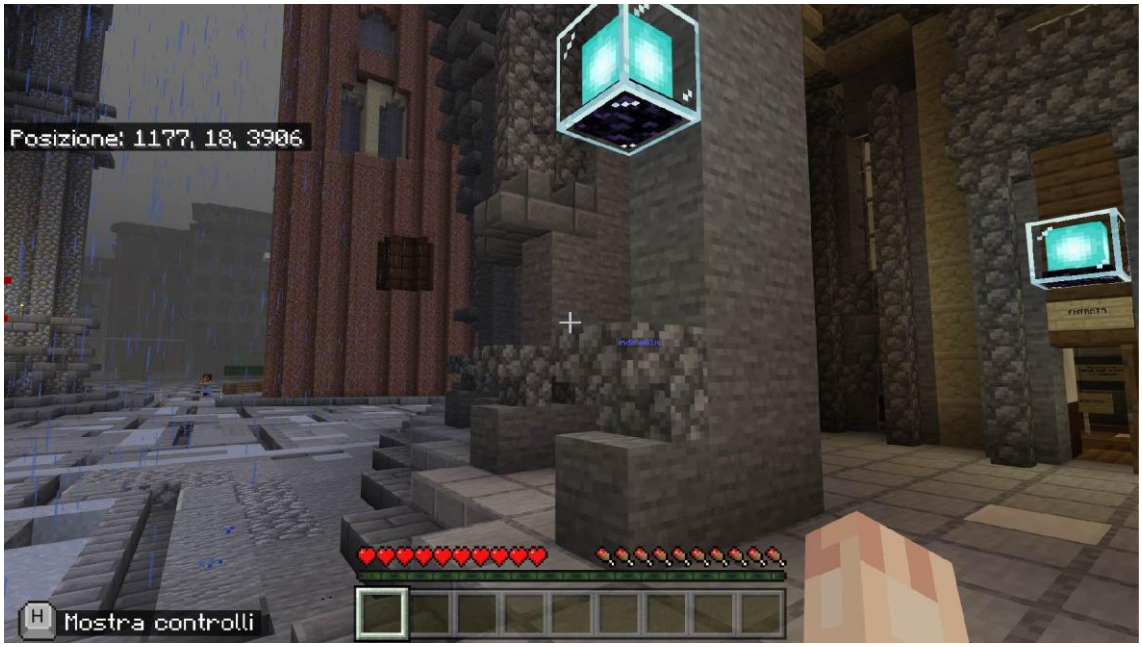

Figure 2. A screenshot of the Uffizi Gallery glimpse in Minecraft.

Evaluation of effectiveness

The use of serious games in the educational and public engagement field are becoming a common practice and are commonly considered effective educational tools in the various stages of growth (Petri et al., 2016). However, the definition of a method of evaluation for the applied approach is necessary. There are few studies in literature that have applied a rigorous method for evaluating serious games, some of them relate exclusively to e-learning. The MEEGA approach (Savi et al., 2011) is the most complete in terms of evaluation of effectiveness and it can be applied to both digital and non-digital game based learning. The considered quality factors are Motivation, User experience and Learning. The factors are decomposed into several dimensions and a questionnaire is constructed and distributed after the game experience.

The MEEGA+ (Petri et al., 2016) is an evolution of the previous method, focused mostly on computing education, evaluation goals are decomposed and a measurement instrument to evaluate the perceived quality of educational games in terms of player experience and perceived learning is defined (Petri et al., 2016).

Egame-flow (Fu et al., 2009) is another approach for the evaluation of effectiveness taken into consideration, it is meant to be applied on e-learning and it's the first method in literature with particular emphasis on fun, in fact, in an effective e-learning game, the learner's enjoyment acts as a catalyst to encourage his/her learning initiative. In addition, Serrano-Laguna (2017) is examined and readapted to provide simplified calculations to read the results of the questionnaire. In order to develop a method for the evaluation of effectiveness, a questionnaire has been implemented, with multiple sections, using the Goal/Question/Metric approach (Basili et al.,1994) to decompose Quality factors into dimensions and items. Its components are: Demographic Information, Previous Knowledge, Player experience, Usability, Learning, Comments and Suggestions.

With demographic information, the educator can outline the main aspects of the user. Previous knowledge is rather useful in defining a certain level of awareness the user has before playing the game. To answer, the player is confronted with multiple questions and a basic True/False (Yes/No) choice. These first two sections do not show into the final evaluation, nevertheless they are useful to give some context and increase the accuracy of the final assessment.

Player experience is a quality factor and it is decomposed in the dimensions of Fun, Satisfaction, Social Interaction, Immersion, Relevance, Focused Attention and Knowledge Improvement. This section is important because if the player experience is enjoyable, the user will remember more about his progressions in the game and acquired knowledge.

Usability is also an important dimension of player experience, but it was decided to place it in a separate section both because it contains others sub-dimensions and because it is easier to calculate the final result, in fact, in this way both Player experience and Usability have the same number of items. The sub-dimensions of usability are Aesthetics, Operability, Learnability and Accessibility, while the other dimensions of the player experience included in the usability section are Confidence, Goal clarity, Challenge and Feedback. The contents of the first two sections measure if the game is Fun and generally enjoyable (Player Experience) and if it is easy to use and accessible (Usability), with a response method through a 5-point Likert scale response from strongly agree to strongly disagree.
The Learning section contains 10 questions based on the LEGO model. This section serves to assess the effective learning of the user during the game and it's the crucial part of the questionnaire in regard to the contents of the game. The response method of the Learning section is through multiple choices, 4 statements for each question. This section is made to be easily modified in perspective of future developments of Minecraft's flood-risk game mentioned above.
The User's Feedback section can be found at the end of the questionnaire and it's a place where the user can express his opinions on the game openly and possibly give suggestions to improve it. After evaluating the player answers Demographic Information and Previous Knowledge are considered to extrapolate a complete analysis of the game regarding the target population it was tested on and to give a qualitative esteem on the player's perceived Learning.

The final questionnaire can be found at the link:
https://drive.google.com/file/d/1sTV04UHL0yOBkaNhEsJ3o5ItTq_zjjRf/view?usp=sharing.

Discussion and conclusions

In this paper we present two different flood risk models to enhance the awareness to flood risk and a questionnaire to evaluate their effectiveness.
The LEGO hands-on model has been shown in several risk awareness initiatives in the context of "Io non rischio – I don't take risks", a national communication campaign on best practices of civil protection. It has also been exhibited in scientific dissemination initiatives such as Bright-Night 2019 and at the Italian FIRST LEGO League regional selections. In December 2018 it was presented at China – Italy Week at the National Museum of Science and Technology "Leonardo da Vinci" in Milan.
Due to its characteristic of using the very famous LEGO bricks, it is aimed at the population of the little ones and reignites the passion of adults for "building bricks".
Each event was an opportunity for the facilitators to explain the dynamics of the floods and the importance of structural and non-structural mitigation measures. Adults and children were involved in risk scenarios set up in the model and the aspects related to the effects resulting from situations and decisions and the importance of good practices in the event of a flood were highlighted. The children may be involved in the scenario management by asking questions, suggesting interventions and virtuous behaviour.
Another way to promote flood risk awareness is through serious games, thus the second flood risk model to be presented is a serious game set inside the Minecraft Education world, that is under development with external collaborators, and it exploits the potential of Minecraft world to create an immersive role-play experience that will be submitted to a group of children of the school laboratory "Scuola-città Pestalozzi" in Florence.
In order to investigate the effectiveness of the proposed flood risk models a questionnaire, based on the MEEGA and MEEGA+ survey methods, have been implemented. In the questionnaire, some items from those methods were replaced with statements from EGame-Flow method and the number of questions was reduced to revise the results examination with the modified version of Serrano-Laguna method. The Learning section was structured on flood risk questions, that is the main object of our evaluation.
The questionnaire is shaped in such a way that it can be easily modified to meet future needs, so that it can be implemented after testing it, in fact, as the next step to this research, we are planning an application of this questionnaire to both the LEGO model from the University of Florence and the new digital game set in the Minecraft world.

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WATER AND ITS SURROUNDINGS WITH THE IBSE METHOD: A METHODOLOGICAL APPROACH FOR DEVELOPING COMPETENCES

Polverini C.[1]

[1]*ANISN Centro IBSE Firenze, cpolve@tin.it*

Abstract

The Inquiry generally refers to a constructivist methodology whose meaning of learning is linked to the construction of a personal knowledge and developed through methods of protagonism in personal training. It spread in Europe following the recommendations enshrined in the Rocard's Report (2007) for which an engaging, effective and efficient method is needed to combat the alienation of young people from studying STEM. The scientific inquiry in the classroom is carried out with a sequence that corresponds to the genera in terms of: Involvement (Engage), Hypothesis and research of evidence (Explore), Explanation and Communication (Explaine, Elaborate).

Through various interventions also in the IBSE type, it is possible to allow our students to understand that water is an essential resource for the life of living beings and specifically for human beings. In this way we will highlight the importance of water purification in our Western societies. After an involvement activity that could be the reading of some data regarding diseases in the world related to poor water quality, students will be requested to design a system to purify pond water in the classroom. Initially, the Investigative question promotes the planning. At the end of the experience, students will have to justify their implementation. The results will be evaluated by the teacher who will give a score for the obtained degree of cleanliness of the water. In relation to the Learning Cycle principle, this experience will push to ask questions thus encouraging the understanding of new knowledge. Finally, through a Debate, it will be possible to address the topic of the individual consumption of the resource and the access to water in the world.

Keywords: Inquiry,IBSE, Investigative question, Learning Cycle, Cooperative Learning.

Introduction

Over the last years, the Inquiry Based Science Education (IBSE) methodology spread in the training centres of the National Association of Teachers of Natural Sciences. Each year, in the 14 centres of the Association teachers are trained for understanding and realising an innovative approach for putting students at the centre of their learning process.

Inquiry, in general, refers to a constructivist methodology which defines the learning process as something linked to the elaboration of a personal knowledge and developed through protagonism activities in the individual formation. The students of all the school levels and scientific areas should have the opportunity of using the scientific inquiry and developing the capacity to think and act according to the research, including put questions, planning and investigating by using adequate instruments and technics for collecting data, critically and logically thinking to the relationship between evidences and explanations, building and analysing the options and communicating scientific arguments (NRC 1996, p. 105).

Inquiry spread in Europe following the recommendations of the Rocard Report (2007) according to which for contrasting the less inclination of young people to study of STEM, it is necessary to rely on a more involving, efficient and effective method.

Basically, inquiry is an active learning process in which students answer research questions through data analysis. It could be argued that the most authentic investigative activities are those in which students respond to their own

questions by analysing independently collected data. However, an activity can still be based on the inquiry when questions and data are provided, on condition that students conduct the analysis and draw their own conclusions. In addition, most students need substantial support before they are ready to develop scientific questions and design effective data collection procedures to answer these questions. (Randy L. Bell, Lara Smetana, Ian C. Binns, 2005). The most appropriate choice for the teacher should be to help students progress towards greater investigative skills through a step-by-step process.

Methodological approach

The Scientific Inquiry is carried out in class with a sequence that corresponds to the general terms of: Involvement (Engage), Hypothesis and evidence research (Explore), Explanation and Communication (Explain, Elaborate). Each of these moments represents a significant phase of IBSE.

In the **Engage** phase, the teacher pulls out the students' previous knowledge and stimulates them on a new concept through the use of short activities that promote curiosity and show the previous knowledge. This moment allows to prepare and to organize the student's mind to respond to the new problems to be faced.

In the **Explore** phase, the activity allows to use the previous knowledge to generate new ideas, to explore questions and possibilities, to design and conduct an investigation that can be preliminary and subsequently, through a correction of previous wrong ideas, more secure. Explore experiences provide students with a common base of activities wherein processes and skills are identified, and conceptual change is facilitated. Students can complete laboratory tasks to use previous knowledge for generating new ideas (Fig.1).

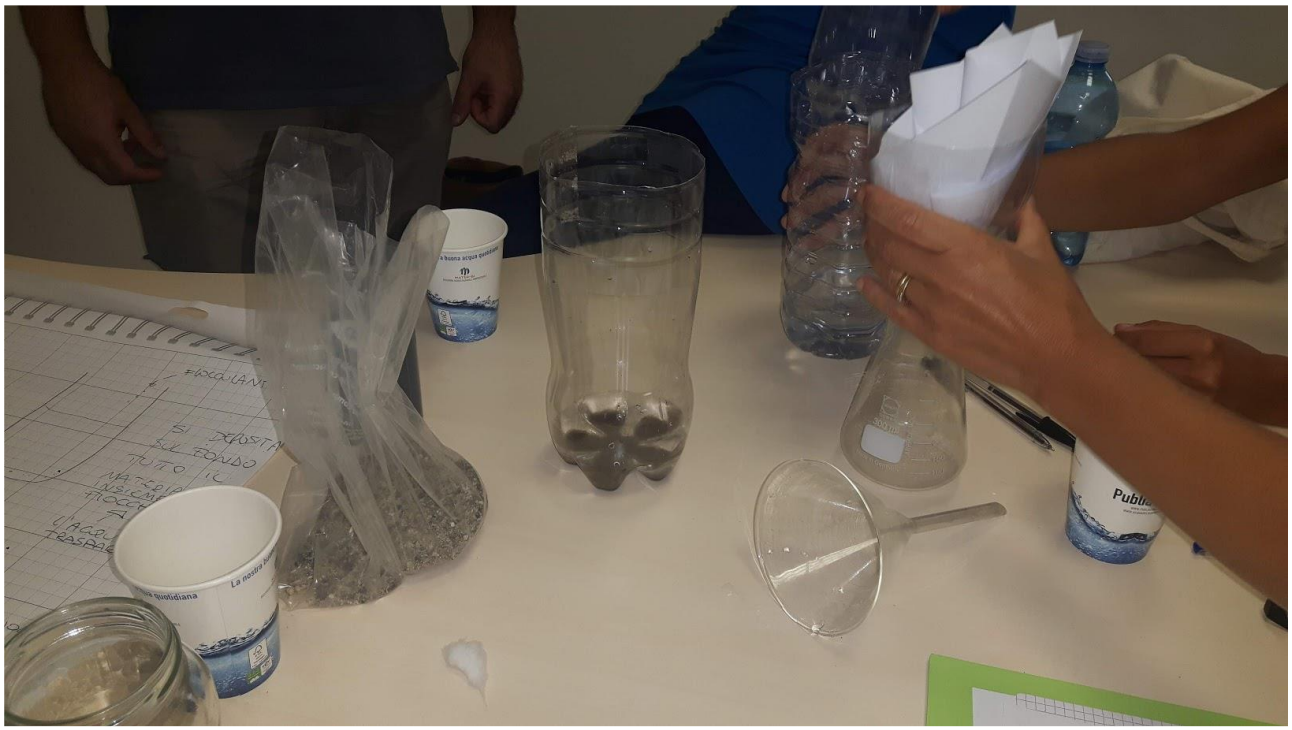

Figure 1. Classroom experience. The image shows some tools used for the drinking water experience.

The Explanation Phase (**Explain**) focuses the attention of the students on a particular aspect of their experiences of involvement and exploration and provides opportunities to demonstrate their conceptual understanding and ability in the realization of the phases of the process of assimilation of knowledge. At this stage, teachers have the opportunity to directly introduce a concept, process or skill or to bring all these elements out of the explanation that can guide them to a deeper understanding, which is a fundamental part of this phase.

In **Elaborate**, teachers test and extend students' understanding and conceptual skills. Students apply their understanding of the concept by conducting additional activities that allow a deeper and broader understanding.

At the end of this course there will be an evaluation (Evaluate) that should encourage students to evaluate their understanding and ability and offer teachers the opportunity to evaluate students' progress towards achieving educational objectives. The focus of this brief discussion will be an example of IBSE activity applied to water as a resource, circumscribing the topic to a useful activity to raise in students awareness about water management in the territory. Every aspect of life depends on water and life itself seems to have originated in water, the chemistry of carbon, that is, the chemistry of life on Earth is inextricably linked to the water medium.
"Where there is no water, diseases and poverty spread. Without water you die, it's a widespread notion that the world does not have a shortage of water at all, but is rapidly leading to widespread shortages of usable water." (Marq De Villiers, 2002).
It is possible to make our students understand that water is an essential resource for the life of living beings and specifically for man and for all men through different interventions in IBSE type. In this example we will highlight the importance of the water purification in our western societies and how, from this activity, it is also possible to extend knowledge and address new topics.
In this phase of **Engage**, it has to be recalled that the learning process based on cases and scenarios involves students in analysing specific scenarios that resemble or are real-world examples.
After an activity of involvement that could be the reading of some data regarding diseases in the world related to the bad quality of water or a comment to an infographic that represents access to clean water, the issue is to encourage students to design a system to purify tin water or otherwise waste water in class.
Hence, students are presented with samples of polluted water with the presence of different materials: mud, plastic, oil, leaves... and asked to take a close look at the water, to evaluate how the sample looks and to note its characteristics on the sheet that has been delivered. *Is the water transparent? What is the prevailing colour? Are there visibly suspended materials? Which ones?*
Different materials on the laboratory bench are also shown: gauze, fine knitted fabric, nets, sand, dishwashing detergent, thermostatic bath, funnels made with the top of a 1.5 liter plastic bottle (in the case of students of the Secondary School also of Activated Charcoal and Flocculant, clarifying their properties).
After having delivered to each group of students an identical sample of water, an investigative question is expressed that promotes the project: *how would you design a sequence of phases using what you have at your disposal to purify the water of the bottle?*
The investigative question is a key moment of the activity because it must allow to realise an experience that finds evidence of what you want to justify, which allows explanations of the scientific phenomenon. The investigative question can also be represented by the design of a model that simulates a phenomenon or process, as in this case.
This is the moment when it will be possible to create learning environments in which it is possible for students to express a Cooperative Learning: students work in groups and discuss their ideas. Some proposed materials may be misleading, but this is also useful for careful reflection. Generally, at this stage students are also entrusted with a worksheet in which to record their ideas and design, are also indicated the times of the various activities. The teacher is the supervisor of this activity and its role is fundamental and will have to gather uncertainties and address students through questions but never giving answers (*What are you doing? Why did you choose this solution?*).
It will thus be found a way to understand the meaning of filtration, and how it happens, or that of decantation (*In your opinion, how does filtration happen according? Why does decantation happen? How does flocculation happen?*). At the end of the experience, the students will have to justify their elaboration. An important trick can be to remind students to keep a sample of water for each of the steps to better understand the effects of the treatment they performed. The samples treated by the different groups will be observed by all and will be compared (colour, smell, etc.) to determine the best method used but also their manual skills.
This comparison will highlight the best choices but also the drawbacks and the difficulties of each working protocol. The results will be evaluated by the teacher through a score for the degree of cleanliness of the water obtained. But some other questions will be asked: *could you say that water is drinkable? Why? Write an explanation of your stance*. Students will therefore be able to reflect that invisible microorganisms or toxic substances may still exist in the water. *And so, what contaminants have been removed? What kind of other procedures should you perform to make drinking water?*

The potability of the water does not correspond to its organoleptic characteristics; even if water appears clear and odourless it could be rich in microorganisms or harmful substances in solution. Drinking water must be healthy and clean, that is it must not contain micro-organisms or other substances in concentrations likely to present a potential danger to human health.
The water that is distributed in our cities is controlled and made drinkable through careful treatments and at this point the spontaneous suggestion is to propose a visit to the Water Treatment Plant and water distribution in their territory.
The sharing of answers to questions throughout the course will allow you to build a summary text enriched by a correct and precise terminology that each student will create in the personal notebook. In relation to a Learning Cycle principle, questions will arise from this experience that will facilitate the understanding of new knowledge.
It will be possible through a debate to address the issue of the individual consumption of the resource or the access to water in the world. Through maps, one could point out that access to water is conditioned by the scarcity of water that in turn is distinct in physical and economic. The term «physical water scarcity» refers to those situations where more than 75% of surface and groundwater is taken, thus exceeding the sustainability limit. The term «economic water scarcity» is used for those areas where there is an abundance of water resources, but the majority of the population does not have enough sanitised water.
Another simple activity "The game of access to water" can be suggested. After distributing sheets with meaningful images that evoke water and its use in various places on Earth, students will be asked to gather in groups and to verify whether in the selected area there is a real access to water by motivating the answers. The tabs with the comments will then be inserted in a planisphere and compared with each other.
It will therefore be easy to deal with the great problem of inequalities in the world for the use of water resources and highlight the data telling that, according to the report of UNICEF and the World Health Organization (WHO) of 2019, one out of three people worldwide continues to suffer from poor access to water and sanitation.
From a local vision we will move towards a global vision.
Time-limits can often discourage teachers because not all experiences have short times and expectations must be filled with discussions and comparisons between the protagonists, i.e. the students. An Inquiry method may seem complex and not easy to apply but if we carefully choose the space, materials and time available, we will choose the activity that we want to propose in this new version, we will find that the response of the students will certainly be positive, much depends on us, on our will as teachers to put ourselves in the game, on our creativity. It is evident that is it essential to have an open mind to other perspectives concerning the individual teaching method.

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Rivers and citizens' participation

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BUILDING A EUROPEAN COMMUNITY OF INTEREST ON INVASIVE ALIEN SPECIES

Gervasini E.[1], López-Cañizares C.[1], Cardoso A.C.[1]

[1]European Commission, Joint Research Centre, Ispra VA, Italy
Corresponding Author: eugenio.gervasini@ec.europa.eu

Abstract

Invasive alien species (IAS) affect all kind of environments, including rivers and lakes in urban areas, putting at risk ecosystems, their services and human activities.

People can actively contribute to early detection and monitoring of IAS trough Citizen Science (CS), helping to achieve the European policy biodiversity goals, including those of the EU Regulation 1143/2014 on IAS.

The European Alien Species Information Network (EASIN), facilitates access to information on alien species occurring in Europe in support to policy and scientific research on IAS. Moreover, it is committed to CS and public engagement through the development of dedicated tools and information material for the public, with focus on the educational and teaching community. A smartphone app "Invasive Alien Species in Europe", a CS projects web page repository, and a communication strategy, including Social Media and participation to science popularization events, aim at creating a European-wide community of interest and participation around IAS issues. In addition, the board game “Have you seen an alien? focused on rivers as pathways of introduction and spread of alien species, has been developed and tested in different contexts with students and teachers.

Our experience shows that direct interactions with teachers and students in science popularization events provides personalized feedback, considering participants´ objectives and expectations. Learning from these interactions greatly helps improving communication with potential citizen scientists, contributes to update the IAS app features, and supports public engagement in the early detection, monitoring, and management of IAS. High attention is dedicated to providing swift feedback to enquiries and contributions from participants, to keep interest around the subject, and promote long-term engagement in biodiversity and ecosystems conservation.

Keywords: invasive alien species, rivers, lakes, freshwaters, citizen science, App, people’s engagement, EASIN.

Introduction

Alien and Invasive Alien species (IAS) occupy all kind of environments, including rivers and lakes in urban areas, and require increasing resources for their monitoring and management. IAS have a negative impact on freshwaters environments as highlighted by Magliozzi et al. (2020), affecting native biodiversity and the provision of ecosystem services. People can play an active role in their detection and can contribute to increasing the scientific knowledge on these species also by collecting updated distribution data through Citizen Science (CS) initiatives.

CS refers to the voluntary participation of people in different phases of the scientific process, including data collection or analysis (Bonney et al. 2009). The European Commission (EC) defines CS as “production of knowledge beyond the scope of professional science, often referred to as lay, local and traditional knowledge” (EC, Science Communication Unit 2013). Participants to CS projects can provide experimental data and facilities for researchers, raise new questions and hypotheses and co-create a new scientific culture (Chandler et al. 2017). While adding value, participants acquire new knowledge, skills and gain understanding of scientific work (EC 2014).

CS has now become a mainstream approach for collecting data on ecosystems and biodiversity (Newman et al. 2012, Tweddle et al. 2012, Chandler et al. 2016, McKinley et al. 2017) and has registered growth and popularity thanks to web-based and mobile technology advancements (Reed et al. 2013). Improved technology facilitates

the collection of massive data (Schade et al. 2019), allowing the definition of species distribution maps and populations trends, including IAS, contributing to scientific understanding of biological invasion phenomena.
People can also engage and actively contribute to the IAS management through involving actively in environmental and educational projects at different levels (local, regional, global) or through adoption of good practices and codes of conduct (Include reference). Freshwater environments, including rivers and lakes, are visited intensively by people for many purposes: recreation (walking, angling, boating, swimming, diving, jogging painting, cycling, meditation, barbecuing …) activities which could motivate CS practise at the same time, allowing multiple observations and reports of alien species over time (e.g. LIFE project Invasaqua, Biological Record Centre UK) .

EU Regulation 1143/2014 on IAS prioritize 66 species non-native to Europe as of Union concern, requiring a concerted action at European level for their early detection, monitoring, eradication and management. 28 species out of 66, including animal and plants, are specifically linked to freshwaters environment, while further more can live or be present in those areas. In this context, CS offers a great potential to supplement the official surveillance operated by EU Members States.

The EU Regulation on IAS incorporates in Art. 26 the dictates of Directive 2003/35/EC fostering public participation to increase the accountability and transparency of the decision-making process, contributing to public awareness on environmental issues and increasing support to implementing measures. The Regulation also foresees in Art. 22 collaboration and exchange of information between MS, including programmes related to public awareness or education. EU MS are requested in art. 24 to report to the European Commission the measures taken to inform the public about the presence of an IAS and any actions that citizens have been requested to take.

Thus, the implementation of EU Regulation on IAS can benefit from the involvement of the public through CS initiatives recording and management of IAS but also confidence in the decision processes (Cardoso et al. 2017).

This work aims to identify current challenges in involving people in IAS monitoring in Europe, with focus on freshwater environments, and to present JRC activities on citizen engagement and CS on alien species and IAS. We present CS and citizens' engagement in the framework of the European Alien Species Information Network (EASIN) and science communication activities targeting freshwater environments, the results achieved in terms of participation and engagement, reflecting on the need of people long term engagement and prioritization of actions. The last section presents conclusions from this study, and points to future directions.

EASIN CS and citizens' engagement

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A thorough review on issues concerning IAS in Europe by Caffrey et al. (2013) puts evidence, amongst other, on the need for new technologies for early detection, early warning mechanisms, and outreach to foster improved IAS management, and effective communication to raise awareness on IAS. On this very last point, Jaric et al. (2020) conclude that "there is a need to devise more efficient communication and outreach approaches regarding the threat from biological invasions", trying to reach all sectors of the population, explaining IAS impact and influence behavioural change.
This is further supported by Shackleton et al. (2019) stressing the importance of understanding the factors that influence people's perceptions to guide future research, facilitate dialogue between actors, and aid management, policy formulation, and governance of IAS. This can help to circumvent and mitigate conflicts, support prioritisation plans, improve stakeholder engagement platforms, and implement control measures.
Effective initiatives on IAS management require the understanding and engagement of the public. (McNeely 2001, Sanz-Aguilar et al. 2020), emphasized the necessity of involving different sectors of society in the management of IAS.
Successful implementation of policies depends highly on the public awareness, attitudes and level of engagement, especially in complex multicultural environments like the European Union.

Pro-environmental behaviour is often influenced by the level of education and exposure to dedicated science communication actions (Meyer, 2015). In addition, raising awareness successfully relies on a multitude of traditional and innovative approaches from printed materials, press releases and public events to social media and other web-based applications.
The EASIN Science Communication strategy goals build on these findings and duly considers people different attitude towards biodiversity and perception of IAS threat, also linked to language and culture. People's sentiments and motivation are crucial aspects considered by the strategy, which aims at supporting policy makers, managers, scientists, social organizations, and stakeholders in the common endeavour of protecting European biodiversity against pressure on natural environment, including freshwater, from alien species introductions, by means of:

- raise people's awareness of IAS impacts and nudging a responsible behaviour as pet owners (e.g. red ear slider turtle have high negative impact on biodiversity and should not be released in nature) and on their role as stakeholders,
- improve citizens' knowledge and science literacy on alien species and IAS recorded in Europe (e.g. freshwaters species factsheets, dedicated news);
- promote engagement and direct involvement in early detection, monitoring and management of IAS (e.g. through the JRC App or joining CS projects listed in the EASIN repository).

The strategy adheres to the founding principles of Citizen Science (European Citizen Science Association, ECSA) and is implemented by means of:
- website containing updated scientific information on alien species in Europe searchable through web services, news, a repository on CS projects in Europe, documentation such as species factsheets and good practices for the management of alien species;
- social Media; aiming to create a community of interest including scientists, citizen scientists and the general public around the topic of alien species;
- the "Invasive Alien Species in Europe" App; involving citizen scientists in the monitoring of prioritized IAS (so-called of Union concern);
- the Board Game "Have you seen an alien?"; engaging school and high school students in the conservation of freshwater ecosystems;
- Massive Open Online Course (MOOC): project under development, targeting the educational community (teachers and students), and the public to increase knowledge, awareness, curiosity, networking capability and stimulate involvement in the monitoring of alien species through citizen science. The MOOC will be available through the JRC EU Academy educational platform in 2021;
- contribution to events with a wide public participation such as European Researchers Night, FOCUS, European Week of Regions and Cities, World Water Day, and engaging in webinars and panel discussions.

In addition, future activities such as Virtual Reality game targeting the educational community (teachers and students) are foreseen to increase knowledge, stimulate interest and engagement through enlightening visualizations.

Results

The results of the EASIN communication strategy are analysed in view of filling the existing knowledge gaps regarding people's perceptions on IAS, and in particular within the educational community, the need of specific targeted communication actions and for supporting a more effective implementation of the EU Regulation across the EU.
Since 2017, the social media community has steadily increased to 1,600 followers on Twitter and 2,200 on Facebook. In parallel, we observed an increasing number of contacts through SM to inform about local initiatives and detections of species and to submit enquiries on scientific aspects or concerning the implementation of the legislation. Citizen engagement through social media have also resulted in a collaboration with volunteers for translating the "Invasive Alien Species in Europe" App (Figure 1) into further languages to extend its possibility of use (PT, HU, BG, SL, FR, TR), bringing the total to 11, in addition to EN, DE, ES, IT, HR. This addresses the problem constituted by the language barrier.

Dedicated news on IAS including those affecting freshwaters have increased the number of visits to the website, This, in addition with the communication via social media contributed to an increasing number of people downloading the App (> 3,000 downloads including updates), and growing number of validated observations submitted via the App (>400);

Figure 1. "Invasive Alien Species in Europe" JRC-EASIN app

- Collaboration with national projects targeting freshwater ecosystems through citizen science: Joint Danube River Survey on IAS and LIFE Invasaqua (Spain) to include species of regional interest in the app local catalogues (64 and 26 respectively), while Malta ERA adopted and branded the App and the project SAVA Ties, Croatia, is adopting this tool;
- Participation to COST Action 17122 Increasing understanding of alien species through citizen science (Alien CSI), deliberative workshops, scientific publication and outreach;
- Updated EASIN catalogue and geodatabase including 760 searchable freshwater alien species coming from data partners, accessible via the website services. (Figure 2).

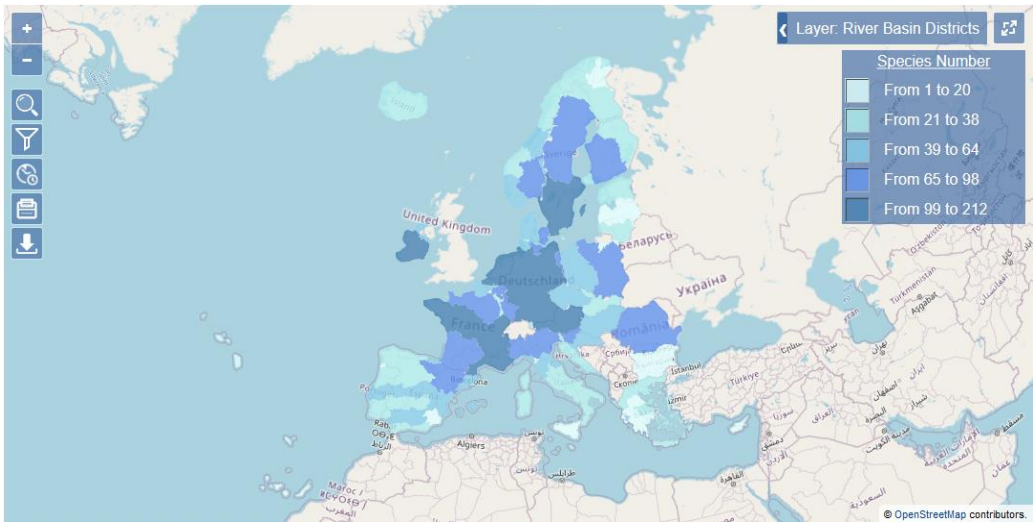

Figure 2. Presence of freshwater alien species in European river basins. Lighters colours indicate a lower number of species, darker colours indicate a higher number of species. Source: EASIN 2020.

- Update of the EASIN online repository on CS projects: 60 out of 110 projects recorded in Europe target alien species in freshwater ecosystems, with France, Germany, Italy, UK and Spain hosting the highest number of projects;
- Increased number of science communication collaborations and participation to events: (GLOBE, FOCUS, European Researchers Night, World Water Day, EU Green Week, European Week of Regions and Cities) also by means of webinars, where the app and the pilot JRC-EASIN boardgame “Have you seen an alien?” have been successfully tested with teachers and students (Figure 3).

Figure 3. JRC-EASIN board game "Have you seen an alien?". World Water Day, Mantova 2019.

- Increased collaboration across Joint Research Centre Directorate and with European Commission services in the frame of biodiversity, citizens’ engagement (ENGAGE Community of practice), apps development and education (context: MOOC under development).

The MOOC

Online learning is a form of distance, web-based learning with synchronous and asynchronous components such as real-time interaction with peers and teachers, participation in virtual classes, allowing to study anytime and anywhere (Aristeidou and Herodotou, 2020).

A Massive Open Online Course (MOOC) is an interactive step-by-step course aimed at reaching an unlimited number of participants worldwide to create a community of lifelong learners, in an effort to make learning as open and accessible as possible (Anderson, 2014).

Aristeidou and Herodotou (2020) reviewing studies on informal online citizen science trainings concluded that learning outcomes include revised attitudes towards science, a better understanding of the nature of science, increased science knowledge, and additional topic-specific knowledge as well as generic knowledge.

Benefits of online courses:

- Online teaching overtakes the need for physical presence;
- Is accessible 24:7 and can reach a broader audience;
- Allow for extending discussion in a blog, via Social media and tailored feedback.
- Access to traditional course materials, such as readings and problem sets, plus interactive tools, such as videos, quizzes, forums, Social media chats and articles can generate and help further discussion and debate.

Considering this approach and the need of adaption of online training materials to the educational community, the main objectives of the pilot JRC-EASIN MOOC Training Course “Have you seen an alien?”: Public’s engagement in the monitoring of IAS in Europe are:

- Raise public awareness on alien and IAS occurring in Europe;
- Share knowledge on the relationship among nature conservation, invasive alien species and human well-being;
- Inform on the EASIN platform scope and services as the crossing point of relevant information on IAS in Europe;
- Promote public participation in the monitoring and management of IAS through dedicated tools and projects, supporting the implementation of the EU Regulation 1143/2014 on IAS;
- Create a community of trainers on the “IAS in Europe” app and a European wide community of interest on IAS.

Conclusions

Garcìa-Llorente et al. (2008), analysing the social component of IAS, conclude that: stakeholders have different perceptions about the impacts and benefits caused by IAS, and different attitudes toward their introduction or eradication should be considered in any decision-making process regarding their management, particularly when developing educational and informative programs. Public awareness campaigns are vital for any successful management problems associated with IAS (Sanz-Aguilar et al. 2020). Thus, the development of public awareness campaigns to support IAS management, sharing information about IAS impacts, devising tools for engaging the public is extremely important. This has been done by means of many EU funded initiatives such as LIFE Projects, e.g. LIFE Asap, and COST actions, e.g. COST Alien CSI.

EASIN approach on science communication and public’s engagement aims at tackling the main difficulties in dealing with IAS, such as language and culture barriers, public’s perception on biodiversity and nature values. The communication strategy was conceived to be inclusive and respectful of people’s sentiments concerning animals and plants across Europe, as a thread for establishing a positive dialogue promoting engagement.

Steady growing direct contacts and followers on Social media have given a positive feed-back towards building a European-wide community of interest on IAS. The translation of the App in further languages, and the planning of

future actions such as the introduction of artificial intelligence for image recognition will foster its use, while the development of Virtual Reality tools will help increasing knowledge and engagement. From the educational side, the preparation of a MOOC can significantly boost the effectiveness of our actions addressing and involving teachers and students of secondary schools. Continuous evaluation and reshaping of initiatives, with involvement of the public in designing and revising actions will further sustain interest on the topic and benefit long-term engagement in native biodiversity and ecosystems conservation in Europe.

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RIVER AS A TRIGGER FOR ACTIVE CITIZENSHIP OF SMALL RURAL COMMUNITIES: A CASE STUDY IN CENTRAL ITALY

Di Lonardo C.[1], Di Lonardo S.[2]

[1]*Earth Sciences Department-University of Pisa, Pisa, Italy, claudia.dilonardo@dst.unipi.it*
[2]*Research Institute on Terrestrial Ecosystems-Italian National Research Council (IRET-CNR), Sesto Fiorentino, Italy, sara.dilonardo@cnr.it*

Abstract

Riverscapes have a crucial role and they must be safeguarded in order to ensure social, environmental and economic development. In order to ensure sustainability, ecological restoration and restoration strategies, the maintenance and improvement of the environmental quality is indispensable and policy makers, scientists and civil society are often today involved in the development of criteria and indicators for environmental governance management objectives. For these reasons, the active participation of citizens is essential to ensure effective protection of the environment at local level, especially in areas affected by the ageing population, emigration and a declining economy. This work explores the weaving of local knowledge, experiences, perceptions, and values of water and place by working with diverse communities and people that know Chiauci, a little village in Alto Molise, in Central Italy. This eco-social research project discovered concerns and needs of a territory through the understanding of the perception by local residents and goers of a recent-built artificial basin, and to consider their adaptation. Structured questionnaire surveys and unstructured interviews were conducted among adults and young people. We critically examined the opportunities and the tensions to people's past, present, and future connections and relationships with the local water environment and their senses of self and/or community. The results showed that drought is a severe crucial climatic event in this area. Moreover, we have identified “top tips” concerning the participatory knowledge and values. These can contribute to co-working with communities to enable and empower citizen engagement with places and local water issues for resilient futures. Local perceptions should be a key to find the process and solutions, by taking into consideration all stakeholders in order to integrate with scientific knowledge. Our findings contribute new understandings of “hydrocitizenship”.

Keywords: dam management, citizen perception, hydrocitizenship, environmental governance, riverscapes.

Introduction

Riverscape includes the features of the landscape which can be found on, along, and around a river. This landscape constitutes an environmental and also a social heritage and, if modified or compromised, it could affect local population. In this context, the construction of an artificial basin is one of the processes that alter an environment and, in general, the landscape. A dam has a great impact on people’s lives and livelihoods (Manatunge et al., 2008) and plays a key role in global, regional and local economic development by serving many purposes such as electricity generation, flood control, irrigation (Tortajada, 2014). The social acceptability of dams is therefore a question of prime importance (Boyé and de Vivo, 2016). Indeed, according to the World Commission on Dams (WCD, 2000), the creation of reservoirs brings certain social benefits but also a multitude of possible disadvantages for the local population which could depend on the size of the dam, its location and population density in the surrounding area. Kirchherr et al. (2016) found out that 93-95% of academic papers on social perception of dams indicate at least one negative social aspect of such projects and only the 5-6% of studies illustrate the positive social impact of dams. The dam has a positive impact for local communities when new prospects for improving their quality of life are proposed (Sivongxay et al., 2017) by enhancing in this way the subjective well-being, facilitate new forms of cooperation among local residents, and economic situation of the region with the development of local tourism (Malek Hosayni et al., 2017). Although there is an increase in literature on the social perception of dams, there are still many under-researched areas around this complex issue

and they require further investigation (Kirchherr et al., 2016) because the publications on social impact of dams are particularly focused on resettlement issues (Kura et al., 2017; Wiejaczka et al., 2020). These studies to a lesser extent deal with the impact of dams on local people who were not subject to resettlement and live in close proximity to dams. Moreover, few papers have addressed age, education and distance between respondents' houses and the dam structure, namely all factors that could have an impact on the perception of dam projects (Wiejaczka et al., 2014). In order to ensure social sustainability, ecological restoration, restoration strategies of these environments, and the improvement of the environmental quality is indispensable and policy makers, scientists and civil society are often today involved in the development of criteria and indicators for the environmental management. The active participation of citizens on these issues is essential to ensure effective protection of the environment at local level, especially in areas affected by the ageing population, emigration and a declining economy.

This work explores the weaving of local knowledge, experiences, perceptions, and values of water and place by working with different communities and people that know Chiauci (41°41′ N, 14°23′ E), a little village in Alto Molise, in Central Italy (Fig. 1).

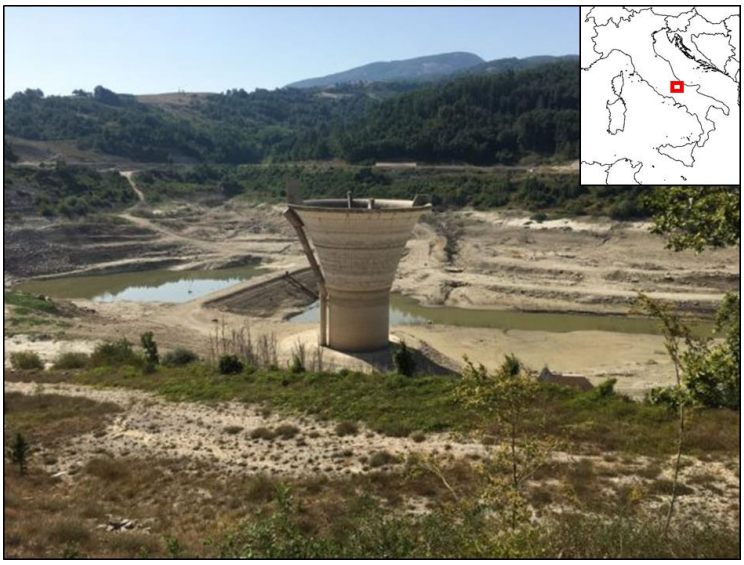

Figure 1.The artificial basin created by the dam close to Chiauci (41°41′ N, 14°23′ E), Italy.

An artificial dam was built close to the village by blocking Trigno river, that drains an area of 1.200 km^2 located for the 40% and 28% in Isernia and Campobasso areas, respectively (in Molise region), and 32% in Chieti surroundings (in Abruzzo region). Its construction started in 1985 and has not been really filled yet. The main purpose of the reservoir was to collect and supply water for the nearby municipality in Abruzzo region and it was supposed to be used for the development of local tourism. In this study, we investigate with a questionnaire the local perception of changes on Chiauci's territory in order to develop solutions that will reduce social costs and maximize benefits of projects linked to the dam by investigating the impact of economic factors (i.e. improvement or deterioration of the quality of life etc.) on the social perception. This study covered the population living in the immediate surroundings of Chiauci dam on the Trigno River. The final aim of this study was to examine people's changing livelihoods and the degree of adaptation and satisfaction by critically examining the opportunities and the tensions to people's past, present, and future connections and relationships with the local water environment and their senses of self and/or community.

Methodology

A survey (questionnaire) administered interpersonally was conducted among people participating at Summer 2020 events in Chiauci (41°41′ N, 14°23′ E) in July and August 2020. The main purpose of this survey was to collect information that would allow arranging the perception and the factors that affect the respondents' declared

opinion about the dam. The questionnaire was custom-built for the objective of the study, containing 21 questions structured in three blocks (Table 1).

Table 1. Variables affecting people's opinions about the artificial reservoir.

Personal variable	Knowledge variable	Emotional variables	Economic variables
age, gender, education, occupation and proximity to the artificial reservoir	general knowledge of the respondents on the presence, importance and management of an artificial reservoir	sense of the security, aesthetic quality perception of the environment before/after dam construction	opportunities for development of nearby villages, environmental impact of the reservoir on the immediate surroundings

The first part of the questionnaire (Q1-Q5) aimed to define the sample population in terms of social-demographic information. The second part focused on the knowledge on the presence and the importance of a dam and its perception (including sense of risk and security), while the third defined the general knowledge of respondents on the importance and the management of an artificial reservoir. Finally, the last part addressed the perception of the environment, such as attractiveness, and the environmental impact of the reservoir on the immediate surroundings. Among the independent variables, we identified:
- emotional variables (factors that have an impact on people's feelings regarding living next to the reservoir: estimation of a sense of security, risk of a disaster, accepting the reservoir);
- economic variables (factors related to respondents' opinions on the viability of the project, benefits for the respondents' village resulting from the investment, environmental impact of the reservoir on the immediate surroundings).

Results and discussion

The descriptive characteristics of the respondents are summarized in Table 2. Out of all the sampled respondents, 65% of them were males while the remaining 35% were females. The age group, equally distributed in all age classes, ranged from 21 to more of 61 years old. The level of formal education among the respondents was high ranging from high school diploma to tertiary education (93%). 49 respondents were employed (78%) and lived in villages close to Chiauci dam (35%) or in other parts of Italy but originated from villages close to the dam. The attitudes provided were generally favourable toward the importance and benefits of the artificial reservoirs to the community (Fig. 2). People placed low (54%) or very low (13%) importance on the presence of a reservoir on a territory; 33% rating importance high (27%) or very high (6%). The importance was significantly affected by education and proximity to the artificial reservoir; generally it rated more important as people' education increased. In Fig. 3 an emotional (level of security) and an economic (environmental perception) variable were analysed. Regarding the level of security (Fig. 3 above), responses were almost equally distributed among definitely unsafe/unsafe (27%), neutral (30%), and safe/definitely safe (43%). A low sense of security may be associated with the real possibility of a catastrophe, i.e. sliding of houses during the earthquake directly to the reservoir (Wiejaczka et al., 2018). In the case of Chiauci reservoir, the high sense of security resulted primarily from a very long period of residence in its vicinity without any incident. Less significant or insignificant were personal variables including distance of respondent's house from the reservoir, as already found by Piróg et al. (2019) for people affected by the construction of the Mucharski Reservoir in the Polish Carpathians. These findings stand in contrast to conclusions drawn by Wiejaczka et al. (2014), who demonstrated that in the case of Klimkówka, another Carpathian reservoir, the main factor determining the social perception of the reservoir was the distance of the house from the reservoir. Indeed, respondents judged negative (29%) or definitely negative (24%) the impact on the environment of the presence of the dam (Fig. 3 below).

Table 2. Descriptive characteristics of respondents.

Variable	Frequency	%
Age	63	100
21-30	21	33
31-40	14	22
41-50	7	11
50-60	12	19
61+	9	15
Gender	63	100
Male	41	65
Female	22	35
Educational qualification	63	100
No education	-	0
Compulsory education	4	7
High school diploma	33	52
Bachelor/Master degree	21	33
Higher degree/PhD	5	8
Occupation	63	100
Student	5	8
Worker	49	78
Retired	5	8
No job	4	6
Address	63	100
Villages close to dam	22	35
Other in Isernia district	9	14
Other in Italy	31	50
Other abroad	1	1

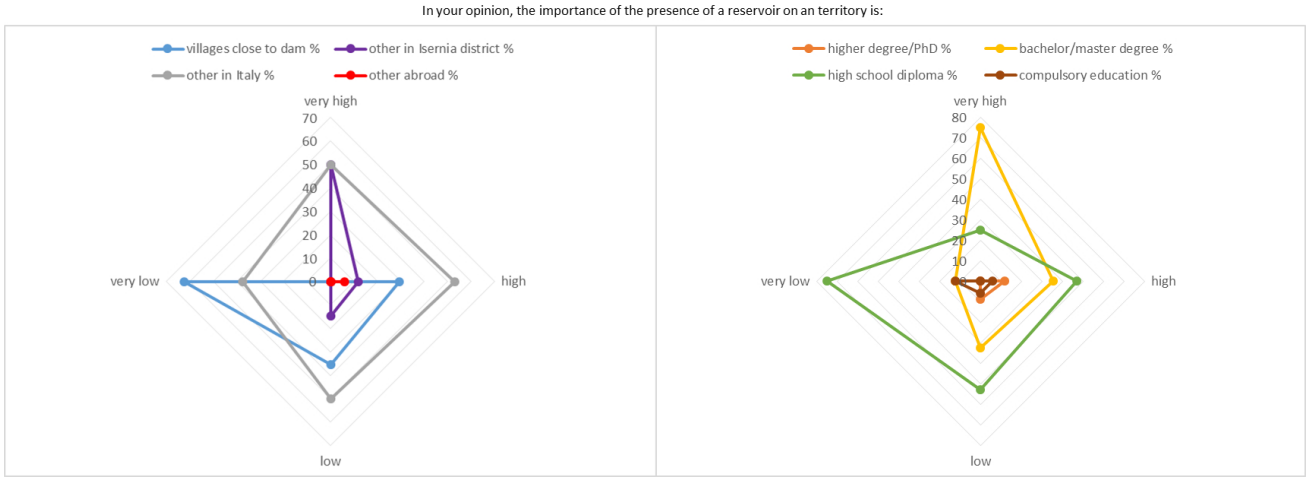

Figure 2. The level of importance associated with the presence of a reservoir in a territory (in percentage).

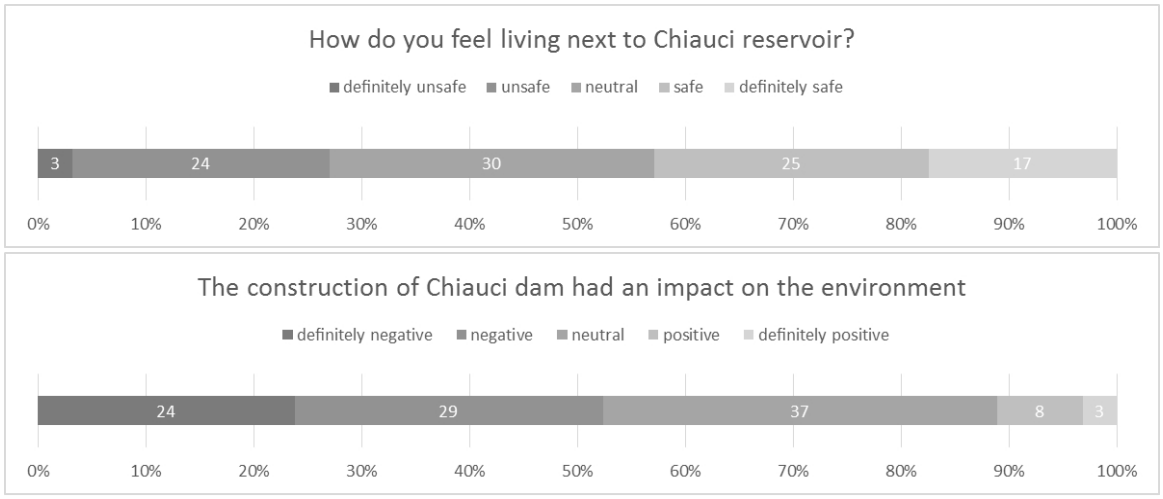

Figure 3. The level of safety (above) and the perception of the impact (below) associated at Chiauci dam (in percentage).

In the comments on this question, respondents wrote the major concern on the environment is the drought that affects Chiauci surroundings since the dam was built. Other concerns were about economic gain by the local population and the passivity of the management authority regarding their involvement (data not shown). To explore this further, we asked with an open question what services/activities thought could be developed for a better use of the area around Chiauci dam. All respondents wrote something demonstrating the great interest in this issue. All the responses have then been elaborated in an online word cloud application (worditout.com). According to this elaboration in Fig. 4, the greater need of this territory are in services, such as tourist facilities in contact with nature and sport infrastructures, that could be a way to relaunch this rural territory affected by the ageing population, emigration and a declining economy. In particular, the development of rural tourism could be a real development factor for these inner areas (Lupi et al., 2017) since it satisfies the need to enjoy nature, and this feature differentiates it from traditional tourism. The development of new forms of tourism in these inner areas could favour a 'proactive conservation of landscape' (Salvatore, 2015) arresting the demographic decline, particularly the decay of working-age groups. A new community-based governance might thus promote the transition from a 'culture of emergency' to a 'culture of prevention' of the territory (Mastronardi et al., 2020) in order to achieve sustainable development through the active participation of citizens.

Figure 4. Services/activities to be developed for a better use of the area around Chiauci dam according to respondents.

Conclusions

We critically examined the opportunities and the tensions to people's past, present, and future connections and relationships with the local water environment and their senses of self and/or community. The need of the local community to participate in the decisions on their territory resulted high. The co-working with communities could enable and empower citizen engagement with places and local water issues for resilient futures. Local perceptions should be a key to find the process and solutions, by taking into consideration all stakeholders in order to integrate with scientific knowledge. Our findings contribute new understandings of “hydrocitizenship”.

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DAYLIGHTING RIVERS
SCIENCE EDUCATION FOR CIVIC ECOLOGY

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A POLLUTED URBAN RIVER AS A RESOURCE TO RAISE CITIZENS' AWARENESS. THE CASE OF THE BESÒS RIVER

Fortuño P.[1,2], Vinyoles D.[2], Fabre N.[2], Verkaik I.[1], Cid N.[1,3], Soria M.[1,2], Bonada N.[1,2], Gallart F.[1,4], Prat N.[1,5]

[1] *Freshwater Ecology, Hydrology and Management (FEHM) research group, UB-CSIC.*
[2] *Departament de Biologia Evolutiva, Ecologia i Ciències Ambientals, Facultat de Biologia, Institut de Recerca de la Biodiversitat (IRBio), Universitat de Barcelona (UB), Barcelona, Catalonia, Spain.*
[3] *INRAE, UR RiverLy, centre de Lyon-Villeurbanne, Villeurbanne Cedex, France.*
[4] *Institute of Environmental Assessment and Water Research (IDAEA), CSIC, Barcelona, Catalonia, Spain.*
[5] *Departament de Biologia Evolutiva, Ecologia i Ciències Ambientals, Facultat de Biologia, Institut de Recerca de l'Aigua (IdRA), Universitat de Barcelona (UB), Barcelona, Catalonia, Spain.*
Francesc.gallart@idaea.csic.es

Abstract

Urban rivers in many Mediterranean countries may run dry due to natural or human causes and/or carry mostly sewage water. The Besòs River, located in the Barcelona metropolitan area (Catalonia, NE Spain) is not an exception, as it drains a catchment highly populated (>2 million people) and industrialised (>10,000 industrial facilities). Except during floods, most of its water comes from several sewage plants. The FEHM research group has been studying its ecological status since 1979. More recently, citizens and schoolchildren have been engaged to contribute to study the river's ecosystem status using the RiuNet smartphone app, which is routinely used two or three times per year. In addition, scientific dissemination activities are realised to raise awareness about the importance of freshwater life, particularly fish.

The construction of sewage plants in the catchment and the channel restoration with wetlands in 1999 have partly recovered the river status. Citizens are now visiting river areas more than ever, and several municipalities have promoted urban river parks. Results obtained by researchers and citizens show that, despite the biological quality has improved and the diversity of autochthonous fish is higher, hydromorphological alterations, point source pollution, and industrial accidents prevent the further improvement of its ecological status. Nevertheless, the social perception of the river has changed, and now, the tools available to schoolchildren and citizens represent a step forward in monitoring and encouraging river restoration.

Keywords: Besòs River, Barcelona, citizen science, environmental education, macroinvertebrates, fishes.

Introduction

Rivers around the Mediterranean Basin are intensively affected by human activities (Cooper *et al.*, 2013; Bonada & Resh, 2013). Human settlements in the area were already present 10,000 years ago and, since then, water diversions, water consumption, landscape modifications, or the introduction of invasive species have not ceased (Cabrera & Arregui, 2010). Therefore, urban rivers have been often polluted in the Mediterranean Basin for many years, especially in their lowlands.

In the western Mediterranean Basin, one of the most human impaired rivers is the Besòs River, located north of Barcelona (Spain). It is a typical Mediterranean river, with seasonal floods and drying periods (Bonada & Resh, 2013). The whole catchment has a surface of ca. 1038 km^2 and constitutes the most populated catchment of Catalonia with >2 million people. The mean annual runoff is small, with a mean discharge value in the lowlands of 5 m^3/s, reaching >2000 m^3/s during floods that mobilise large amounts of sediment (Liquete *et al.*, 2007; Palanques *et al.*, 2017). There are no large dams, but small weirs for irrigation or hydropower are present (Robles *et al.*, 2002). The river begins with the confluence of the Congost and the Mogent rivers and has a length of 18km.

All along its length, the Besòs flows through a highly industrialised area, and it reaches the Mediterranean Sea after crossing the municipalities of Montcada i Reixac, Santa Coloma de Gramenet, Sant Adrià del Besòs and Barcelona. In this lower part, the Besòs River is considered an urban river.

Figure 1. Aerial view of the lower urban reach of Besòs River and its River Park. In black: municipalities. Dark blue mark: Study site of the official data and collaborative fishing activities. Light blue marks: citizen study sites with Projecte Rius and RiuNet. Basemap: GoogleEarth®

Among '70s and '80s, evidence showed that the Besòs River was the most polluted watercourse in Mediterranean Europe (Prat & Rieradevall, 1992; Palanques *et al.*, 1998; Huertas *et al.*, 2006), as a result of the impacts in the whole catchment exacerbated by low flows or dry riverbeds in summer. Until the 1960s the agricultural activity was predominant along the Besòs River and occupied most of the available land. In 1975, after the 1962 catastrophic flood, a hard channelization of the lower river reach was built, which conditioned its further design. Later, the industry gradually spread and occupied the agricultural land, with chemical, metallurgical, plastic, leather, textile, material for the construction, paper and food facilities, accumulating almost 10,000 potentially polluting establishments. During the '90s and 2000s, new water treatment regulations resulted in the implementation of 24 water treatment plants (industrial and urban) that significantly improved the chemical and biological quality of the river (Palanques *et al.*, 2017; Fortuño *et al.* 2019). This improvement was also enhanced by efforts on restoration and rehabilitation actions in the lowland areas, and the implementation of the Water Framework Directive at the beginning of the XXI century (WFD; European Commission, 2000).

In 1996, after the celebration of the Barcelona'92 Olympic games, the four riverine municipalities in the Besòs promoted the development of a 'daylighting' project that included the transformation of the lower course of the river into a river park. The river park was inaugurated in 2004 and consisted of a wetland area to improve water quality (not open to the public) and a mid-lower section accessible for citizens, with green areas and paved sections and 5.5 km of bike lanes. It is visited annually by 1,070,000 pedestrians and 1,030,000 cyclists (Consorci

del Besòs, 2015) estimated with a health-related economic cost reduction of 23.4 million euros per year (Vert *et al.*, 2019).
The attraction of the Besòs River by citizens has also been matched with the implementation of several dissemination activities and citizen science projects in the area. This provides data on the quality of the fluvial ecosystem and its biodiversity, complementing the studies carried out by the administration and research centres. In this work, we present the historical data series of the water quality, biodiversity, riparian forest quality and fluvial habitat heterogeneity of the urban reach of the Besòs River from all these studies.

Methodology

The urban reach of the Besòs River selected in this study is located just after the confluence with the Ripoll River until the Mediterranean Sea, and belongs to a water body (i.e. Catalan Water Agency code: 1100300) that has been routinely monitored in the same site (Fig. 1) by two institutions using official methods: the Catalan Water Agency (2008-2017) and the FEHM research group (1979-2007, 2019, and 2020). These studies provide a long-time series of official data about the evolution of the ecological status, using macroinvertebrates as bioindicators (IBMWP) (Alba-Tercedor & Sánchez-Ortega, 1988), the quality of the riparian forest (Munné *et al.*, 1998) and the heterogeneity of fluvial habitats (IHF) (Pardo *et al.,* 2002) as hydromorphological indicators. In addition, data coming from two citizen science projects developed in the urban reach also provide long-time series of data: Projecte Rius (www.projecterius.cat) (2005-2020) and RiuNet (www.RiuNet.net) (2015-2020) (Fig. 1). Both initiatives have similar methods for assessing river water quality, using macroinvertebrates as bioindicators, riparian forest quality, and instream habitat heterogeneity with simplified protocols from the official methods. These data were usually taken during environmental educational activities, often organised as festive events (Fig. 2), and conducted by municipalities, schools, community centres, or NGOs of the near neighbourhoods.

Figure 2. Left: RiuNet & Projecte Rius stand in the “Science Safari” of the City&Science Biennal organised by Culture Institute of Barcelona City Council in February 2019. Right: Collaborative fishing event stand in Santa Coloma de Gramenet in May 2018.

In addition to the described data collection, during the last 10 years different municipalities also organised collaborative fishing events in the Besòs River Park. These events consisted of a demonstration of fish sampling by electrofishing, fish identification and measuring (after being anesthetised) in which citizens have the chance to observe fish and interact directly with scientists (Fig. 2). These activities aimed to show citizens how fish had returned to the lower urban reach of the Besòs River, which were absent during the ’80s.

Results & Discussion

Official data

During the ’90s, macroinvertebrates were absent (IBMWP = 0) and at the beginning of the 2000s, the biological index IBMWP had values under 10, meaning a very bad biological quality (Fig. 3). Only the pollution tolerant macroinvertebrates of the family Chironomidae were present. Since 2006, the IBMWP value started to increase and reached a moderate biological quality in 2010. Since then, the water quality has fluctuated between the bad and the moderate ranks, but it never came back to the poorest values observed in the past. Nowadays, the river

has a macroinvertebrate community composed of several families of Mollusca, Diptera, Ephemeroptera, Trichoptera, Hidudinea and Isopoda, even though the good biological quality required by the WFD has not yet been reached.

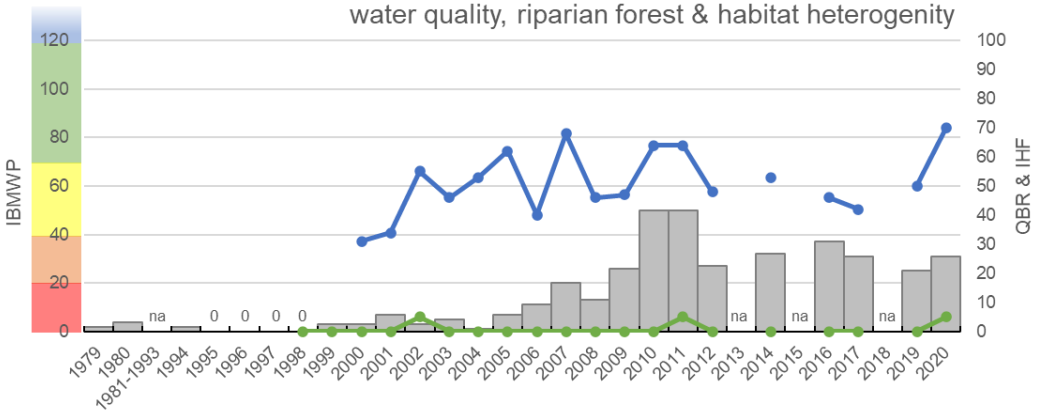

Figure 3. Grey columns: Biological quality values with the IBWMP index; Green Line: Riparian Forest Quality (QBR); Blue line: Fluvial Habitat Index (IHF). Background colours in the left axe indicate the five quality classes of water quality using the actual thresholds set by the Catalan Water Agency (ACA) according to the WFD. Blue: very good; Green: good; Yellow: moderate; Orange: bad; Red: very bad. na: data non-available. Data source: Fortuño *et al.* (2019).

The quality of the riparian forest was very bad (less than 25 points) throughout the entire data set, even after the implementation of the restoration and rehabilitation projects (Fig. 3). These projects were designed as gardens or parks, not as natural riparian forests and, therefore, there is a lack of natural riverine elements (trees, bushes, halophytes, or connectivity with adjacent ecosystems) that, if present, would increase the index values. The instream habitat heterogeneity values shifted between bad (<40), moderate (40-60) and good quality ranks (>60) (Fig. 3). Therefore, habitat heterogeneity is still not enough to sustain rich macroinvertebrates or fish communities.

Citizens' data

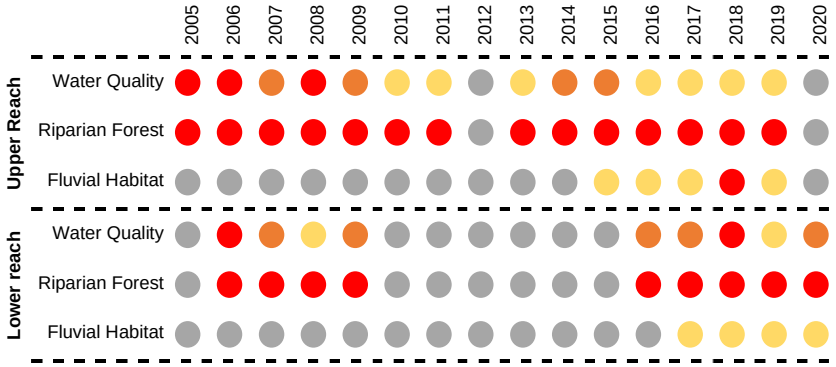

Figure 4. Summary of the quality results of the studies carried out by citizens in the lower urban reach of the Besòs River upstream and downstream the official site (see Fig. 1). Quality colours are the same as in Figure 3. Grey dots indicate that data is not available. Data source: Projecte Rius & RiuNet websites.

Engaged citizens visited the lower urban reach at 11 different sites (upstream and downstream of the official site, Fig. 1), and provided data with Projecte Rius (2005-2020) and RiuNet (2015-2019). Data provided by citizens agreed with official data regarding water quality, and showing an improvement since 2010, especially in the upstream area (Fig. 4). They were also consistent in assigning a very bad quality of the riparian forest and moderate or bad habitat heterogeneity (Fig. 4).

Data collected during the fishing events showed that five species of fish were found in the Besòs River Park, three native (*Anguilla anguilla, Squalius laietanus* and *Barbus meridionalis*) and two introduced (*Cyprinus carpio* and *Cobitis paludica*). None of these species lived in the Besòs in 2002. The abundance of both native and non-native species of fish increased since 2015 (Fig. 5), but was more gradual for non-native fish In fact, these increase, was noticeable during the last two years of the study (2018 and 2019), when high densities of *A. anguilla* and *S. laietanus* were found. The proportion of non-native fish increased when *C. paludica* was translocated to the Besòs River from the Ebro basin in 2016. Indeed, peaks of abundance of non-native species that appear to be well adapted to pollution are frequent in the lower urban reach of the Besòs River (Vinyoles *et al.,* 2017).

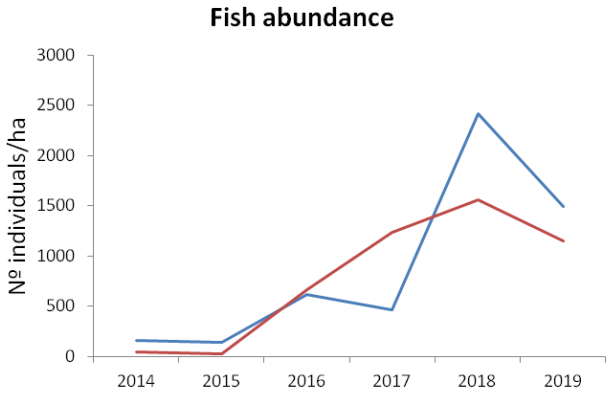

Figure 5. Abundance of native (blue line) and non-native fish (red line) in the Besòs River Park near Santa Coloma de Gramenet between 2014 and 2019.

Conclusion

Managing a highly industrialised and urbanised Mediterranean river is a challenge. During the low flows or dry periods, most of the water carried by the river is often coming from effluents from water treatment plants, hampering the achievement of good water quality. Despite wastewater treatment plants contributed to improving the biological quality of the lower urban area of the Besòs River, the restoration and rehabilitation actions do not seem to have improved the hydromorphological quality. However, they have contributed to attracting citizens to a river in a section that was ignored or avoided during many years.

The mid and long-term objectives for achieving a real daylighting of this urban river need to focus on the improvement of the ecological status (including at least both, the biological and hydromorphological quality) and to keep raising citizen awareness on the ecological, educational and social importance of these urban reaches. Promoting data collection (by managers, scientist, scholarships and citizens) is key to engage citizens to these often-overlooked urban ecosystems and to monitor long-term changes on their ecological quality.

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Science and environmental awareness on water bodies

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RIVERS IN THE CITY OF IRKUTSK (EAST SIBERIA, RUSSIA) AS OBJECTS OF PUBLIC ENVIRONMENTAL MONITORING DURING EDUCATIONAL AND RESEARCH ACTIVITIES OF STUDENTS

Penkova O.G.[1], Tupitsyn I.I.[2]

[1] *Pedagogical Institute of Irkutsk State University, Irkutsk, Russia, e-mail olg-penkova@yandex.ru*
[2] *Pedagogical Institute of Irkutsk State University, Irkutsk, Russia, e-mail itupitsyn@rambler.ru*

Abstract

Educational and research activities aimed at studying the ecological state of the rivers and water bodies in the city of Irkutsk (East Siberia, Russia) are an effective tool in environmental education. Irkutsk is a large industrial city and transport hub, through which the large Angara River flows, originating from Lake Baikal, as well as the small Irkut, Kaya and Ushakovka rivers. The development near banks and in the water protection zone, domestic wastewater and landfills along the banks are serious problems for urban rivers. For ten years, students of Pedagogical Institute of Irkutsk State University have been monitoring the rivers of Irkutsk within the practical classes in biology, hydrobiology and nature protection. Bioindication methods are used to assess water quality. The obtained results demonstrate an improvement in the state of the Irkutsk rivers. Lecturers and students of Pedagogical Institute made several recommendations for improving the environment in the city in the section concerning urban rivers during the public discussion of the site plan of Irkutsk. They prepared recommendations for carrying out public ecological monitoring of the small rivers in the city. Students receive information about the ecological state of the urban environment during fieldworks, actively participate in the educational process and gain practical skills in the behaviour in the environment.

Keywords: Irkutsk, urban rivers, pollution, monitoring, bioindication, environmental education

Introduction

Environmental education of the younger generation should be based on the practical activities of students. Education through the activity method has shown its effectiveness in the formation of environmental competence, environmental culture and environmental outlook. Numerous environmental problems, both global and local, require immediate solutions at the state and personal level. The problem of clean water is currently important among the problems caused by human economic activity. Educational and research activities aimed at studying the ecological state of small rivers and water bodies can combine the issues of environmental perception and education with specific practical steps to improve the ecological state of various water bodies, including small urban rivers.

In the Angara region, there are many small rivers that flow through densely populated and industrially developed areas. Irkutsk is a large industrial city and transport hub. It is located 70 km from the world-class freshwater body, Lake Baikal. The population of Irkutsk is 620 thou people. Irkutsk has a wide hydrographic network. The Angara River flows through the city, which originates from Lake Baikal. Small rivers, Ikrut, Kaya and Ushakovka, flow within the city. The Irkutsk Reservoir has large bays that serve within the city as sites for water intake, recreation and water transport. The development near the banks and in the water protection zone, domestic wastewater and landfills along the banks are serious problems for urban rivers. State and departmental organizations control the quality of the environment. However, this is insufficient to assess the ecological conditions of urban rivers. For ten years, students from Pedagogical Institute have been monitoring the Irkutsk rivers during practical classes in biology, hydrobiology and nature protection. Observations include chemical analysis of river waters as well as monitoring of the level and temperature of the water. Bioindication methods are used to assess water quality. The research results are analysed in term papers and theses as well as published in proceedings of scientific

conferences (Penkova, Igosheva, 2008; Penkova, Sarapulova, 2011; Kaporikova, 2020). Lecturers and students of Pedagogical Institute made several recommendations for improving the urban environment of Irkutsk and developed a methodology for monitoring water quality (Penkova, Evsikova, 2018).

Methodology

Scientific institutes, as well as the Irkutsk Service for Hydrometeorology and Environmental Monitoring, carry out monitoring of water quality in the small rivers of Irkutsk. The research results are published in scientific papers and materials of state reports “On the condition of the environment in the Irkutsk region ...” (Barkhatova O.A et al., 2013**,** State report, 2019). In the area of Irkutsk, water in the Ushakovka River is class 3, category a, i.e. polluted. Within the framework of monitoring of water quality in the Irkutsk rivers, the studies are also carried out in some scientific institutes, public environmental organizations and educational institutions during additional classes in natural science. For over ten years, Pedagogical Institute of Irkutsk State University has also been involved in hydrobiological monitoring of water quality in rivers. Students of the Department of Natural Sciences organized experimental research to study the quality of the environment together with pupils of seventh and eighth middle-school grades as part of extracurricular activities in biology.

This study aimed to determine water quality in the Ushakovka River by the bioindication method. The assessment of water quality began with a biological examination. The biological examination is applied for the initial understanding of the pollution distribution, preliminary assessment of the overall pollution and clarification of the prerequisites for allocating sampling stations (sites) on a monitored water body. It is most advisable to conduct the biological examination from June to September when flora and fauna are most densely developed in water bodies, and the self-purification processes are the most intense (Penkova, Evsikova, 2018).

The description and assessment of the ecological condition of a water body include the name of the river, its geographic location, morphological characteristics of the water body (length, width and depth), flow rate, the temperature near the water surface, and type of bottom soil (determined visually). The type of bottom sediments can be approximately determined on a special scale directly in the water body. Smell, colour, transparency and hardness of water are determined by organoleptic methods. Water acidity can be measured using portable test kits or pH-indicator strips. In the monitoring of the river condition, it is important to describe the form and intensity of the economic use of a watercourse as well as its pollution sources. Evident signs of the anthropogenic impact on the water body (film from petroleum products, smell, decrease in fish catches, fluctuations in water level, erosion of banks, water bloom, suffocation, etc.) should be indicated on the map (Penkova, Evsikova, 2018).

Almost all groups of organisms inhabiting water bodies and watercourses can be used for the hydrobiological analysis of water quality: planktonic and benthic invertebrates, protozoal algae, macrophytes, bacteria and fish. Each group of organisms as a biological indicator has its advantages and disadvantages that determine the boundaries of its use for bioindication purposes. To determine water quality for educational purposes, we use the macrozoobenthic organisms as indicators. Zoobenthos serves as a good and sometimes the only bioindicator of water pollution (Shuiskiy, Maksimova, Petrov, 2002). The number of animal species (in case of large macrozoobenthic objects) in freshwater fauna is small, and it is not difficult to investigate them. We used identification tables adapted for the water bodies of Siberia (Keys…, 2016; Penkova, Evsikova, 2018).

Macrozoobenthos samples collected during the open-water season from 2008 to 2019 at different stations of the Ushakovka and Kaya rivers flowing through Irkutsk (Russia) were the research material. Sampling was carried out with a benthos net made of closely woven gauze. For quantification of macrozoobenthos, a frame with an area of 0.04 m2 was used. The collected material was fixed with 4% formalin. Subsequent processing was carried out in the laboratory of Pedagogical Institute of Irkutsk State University.

The first sampling site was located in the upper reaches of the Ushakovka River where the anthropogenic pressure is practically minimal. The second site was determined at the 17th km of the Irkutsk – Bolshoye Goloustnoe highway. The anthropogenic pressure in this area increases. The third site for the studies of zoobenthos was in Irkutsk near the vehicle marketplace. The degree of anthropogenic pressure here is significant. The final site was located at the estuary of the Uskakovka River close to the city centre and diverse marketplaces with increased anthropogenic pressure.

Results

Investigations of the Ushakovka River revealed more than 11 groups of zoobenthos: Molluska (Gastropoda and Bivalvia), Trichoptera (larvae), Plecoptera (larvae), Ephemeroptera (larvae), Chironomidae (larvae), Coleoptera (larvae), Nematoda, Hirudinea, Nepomorpha, and Oligochaeta. The detected taxonomic groups are typical representatives of the bottom fauna in the water bodies of Siberia. Oligochaeta had the highest quantitative development at the stations located in the city. Among them, there was the pollution-resistant species Tubifex tubifex (Muller). Chironomidae were also numerous (Fig. 1).

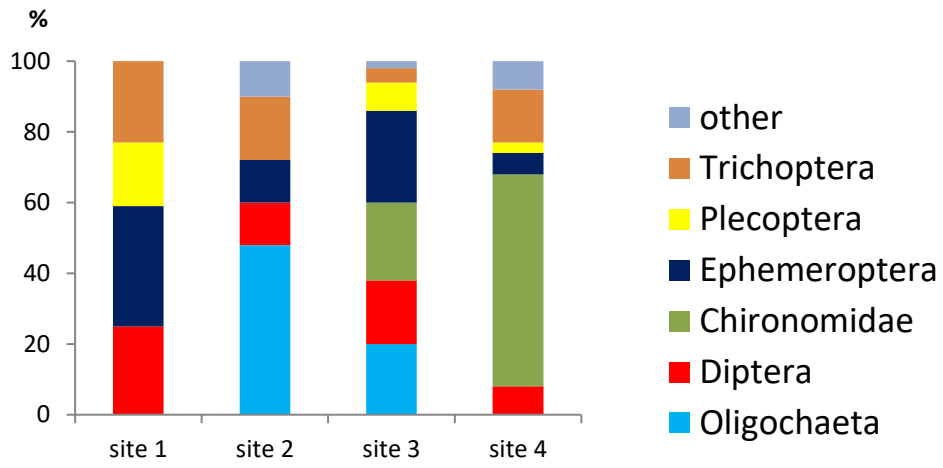

Fig. 1. Composition of zoobenthos at different sites of the Ushakovka River

The was a change in the dominant groups of zoobenthos in the Ushakovka River. The inhabitants of clean waters, Ephemeroptera (larvae), Plecoptera (larvae) and Trichoptera (larvae), were typical of the upper reaches of the river (before Irkutsk). At the stations in Irkutsk, Oligochaeta dominated (up to 50 % of the total abundance of zoobenthos), and Ephemeroptera (larvae) sharply decreased (down to 10% of the total abundance). At the river estuary, where the river flows into the Angara River, there was a high diversity of organisms. As expected, Chironomidae (larvae) were numerous there, and Trichoptera (larvae) and Ephemeroptera (larvae) were also significant. Long-term studies of zoobenthos in the Ushakovka River from 2008 to 2019 indicate that species diversity of bottom organisms has not changed significantly. The bottom community of the Ushakovka River can be characterized as Chironomidae-Oligochaeta. Changes in the abundance of zoobenthos ranged from 22.9 ind./m^2 to 93.1 ind./m^2. To assess the water quality, we tested several methods (saprobity index, Woodywiss index, Mayer's index, and Goodnight-Whitley Index for oligochaetes). In our methodological guidelines, we describe the advantages and disadvantages of each method. Woodywiss index yields the best results for determining water quality. Its positive aspects are widely known: it does not require identification of organism species; net sampling materials can be used, and it is perfect for river investigations. Woodywiss index allowed us to classify the water from the Ushakovka River as very and moderately polluted from 2008 to 2012 as well as moderately polluted from 2018 to 2019. At the same time, in 2017 we classified the water in the Ushakovka River as very polluted.

The structure of macrozoobenthos in the Kaya River during the study years showed the fewer number of groups compared to the Ushakovka River, namely, Oligochaeta, Molluska (Gastropoda), Hirudinea, Ephemeroptera (larvae), Chironomidae (larvae), Coleoptera (larvae), and Amphipoda. The highest diversity of benthos was in the middle of summer (seven groups in July), which gradually decreased by September. In late August, we recorded the highest zoobenthos abundance of 195 ind./m^2. Oligochaeta was the bulk of the zoobenthos abundance in the Kaya River, whose number increased by the end of summer. Woodywiss index allowed us to mostly classify the water quality in the Kaya River as moderately polluted.

The pollution degree largely depends on the types of economic use of the coastal area and the nature of the

anthropogenic impact. Illegal dumping and waste left by vacationers on the river banks are one of the causes. To solve this problem, pupils and students regularly collect solid waste on the river banks. At that time, explanatory conversations are held for them about the problems of waste utilization, methods of their recycling, the concept of waste-free production, and the possible use of waste as raw material and energy. Young people will learn about the environmental problems of Irkutsk as well as the measures developed for improving the conditions of natural resources and reducing the environmental pollution. Rivers and water bodies are interesting ecosystems that acquaint the pupils with the basics of bioecology, the biodiversity of aquatic biotopes and interactions between species inhabiting these biotopes. The children become aware of the fact that rivers are home to many organisms, and it is important to preserve them from destruction or inappropriate transformation.

Students of Pedagogical Institute together with the Irkutsk pupils participate in scientific and educational public project called Environmental Patrol. This All-Russian project provides for a system of environmental patrolling, monitoring of the ecological condition to determine its changes and the effect of human activities on it in the residence places of the project participants.

Environmental problems can be discussed both within training classes and extracurricular activities, for example, at meetings of the ecological club. Thus, in Pedagogical Institute, there is such an ecological club. Students and lecturers take part in the work of this club and invite scientists and experts from various organizations occupied in the field of nature protection environmental safety and environmental management.

The initiated activity has developed with the involvement of the ecological club in the implementation of the international Eco-Schools Green Flag programme. The Environmental Council of one of the departments in Pedagogical Institute and the ecological club represent the coordinating centre for implementing this programme. The Environmental Council decides to work on the most relevant issues based on an assessment of the ecological condition. For instance, it decided to include such issues as climate change, waste reduction and conservation of biological diversity in the work plan.

Students actively participate in various All-Russian events and local environmental campaigns. In particular, they are involved in cleaning the shores of Lake Baikal and urban rivers from solid waste as well as in educational activities in collaboration with representatives from the Department of Environmental Education, Zapovednoye Pribaikalie (Protected Baikal region), in specially protected natural areas and urban natural areas that comprise the green frame of the city.

Conclusions

Therefore, students of Pedagogical Institute in cooperation with Irkutsk pupils participate in environmental campaigns, such as cleaning the shores of water bodies, excursions to nature, etc. Students can be seriously engaged in environmental monitoring of water bodies using various instruments to study properties of the water as well as bioindication methods. Monitoring of the water quality in the small rivers of Irkutsk revealed a decrease in the pollution level. We prepared guidelines for monitoring water bodies (Penkova, Evsikova, 2018).

Design and research activity is a promising area of training. This is interesting for pupils and can involve interdisciplinary topics, which is especially important in the study of environmental problems. Research activities can be implemented within the framework of educational programmes for basic subjects during additional (extracurricular) classes as a school educational project. Thereby, the opportunity is provided to interest students in the topic of preserving water resources and the natural conditions of urban rivers, their stability and biological integrity.

We hope that in the future, the state environmental control departments will take into account the results of public environmental monitoring for decision making.

Therefore, students not only receive information about the ecological condition of the urban environment during fieldworks but also participate in the educational process and gain practical skills in behaviour in the environment. Such training becomes a basis for the formation of motivation for their involvement in various activities to preserve the environment.

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DAYLIGHTING RIVERS
SCIENCE EDUCATION FOR CIVIC ECOLOGY

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THE RIVER AS AN OPEN-AIR CLASSROOM FOR ENVIRONMENTAL EDUCATION: EXAMPLES FROM AN ITALIAN HIGH SCHOOL

Leoni F.[1], Bianchi N.[1], Galdenzi S.[1]

[1] *Liceo Scientifico "Leonardo da Vinci", Jesi (AN) Italy*
leoni.francesca@liceodavincijesi.edu.it; bianchi.nadia@liceodavincijesi.edu.it;
galdenzi.sandro@liceodavincijesi.edu.it

Abstract

The fieldwork activities, concerning different aspects of the river environment, were planned to help students acquire experimental investigation methods and develop "scientific citizenship". Moreover, questioning the connection between the investigated environmental issues and human health contributes to acquiring awareness of the role of the human community on earth.

The project was planned and carried out in collaboration with researchers from local Universities, who supported field work and laboratorial analyses and involved 16 and 17-year-old students from Liceo Scientifico - Scienze applicate, in accordance with the indications of this curriculum. The activities carried out by third year students analysed different aspects of the river ecosystem, with a biological approach: (i) a study of the macro invertebrate inhabitants of the river and the soil nearby as an index of its ecological quality; (ii) a chemical analysis of the river water to establish the water quality; (iii) sampling and analysis of freshwater microalgae, with an in-depth analysis of toxic micro algae. The activities planned for fourth year students (the latest were not carried out due to lockdown related to Covid.19), looked at the influence of the geological conditions and groundwater recharge on the chemistry and discharge of the river.

The students appreciated working alongside university researchers and felt they were generating real scientific data: for these reasons they were highly motivated and focused while collecting samples, performing analysis and discussing results. Following the practical work, many different aspects of river life came up during classroom discussions which contributed to developing ideas regarding the issues addressed.

Keywords: Liceo Scientifico - Scienze Applicate, science education, laboratory-based learning, river environment, open-air learning, citizen science.

Introduction

Investigation-based teaching increases interest in science: in particular, Inquiry-Based Science Education (IBSE) is proven to be effective to improve student's interest and performance, but also to enhance teacher's motivation. IBSE is an inclusive approach since it is effective with all students, from the weakest to the best, and it is compatible with the achievement of levels of excellence (E.U. Rocard Report, 2007). Teachers play a crucial role in the renewal of science education. Collaboration between them and university researchers, allows teachers to improve the quality of their teaching and motivates themselves and students, who learn more effectively "how science works". Working on the processes of science is also what the 2010 high school guidelines also highly recommend (MIUR, 2010). In addition to that, school can play a crucial role to build up "scientific citizenship". Involving students in practical research, together with university researchers, can achieve this goal. Collecting, sharing, discussing scientific data, make them the real leading actors of the various stages of the research process. The exposed projects are some examples of the possibility given to students to build up scientific citizenship (Elam, 2003).

The project was developed in order to characterize the applied sciences course of the Liceo Scientifico "Leonardo da Vinci", Jesi (Marche Region, Italy), according to the guidelines of this curriculum, (MIUR, 2010) and involved 16-17 years old students (3rd and 4th year). The aim of the activities was to strengthen science process skills and

the experimental method of investigation. Moreover, we believe that observation of phenomena concerning the environment and human health, leads to acquiring awareness on the role of the human community on earth. In detail, the specific goals of the project were to let the students know how to set up experimental investigations, identify dependent and independent variables and experimental controls, deal with different sampling methods and data analysis and, finally learn how to draw conclusions from the data. The time spent in these activities was considered valid for PCTO (Pathways for transversal skills and orientation) together with the experiences carried out at companies and professionals.

The project took place in a river, an ideal setting to investigate under many levels, issues related with environmental health, pollution, climate changes and biodiversity, problems that are often put aside during the course of studies but of crucial importance.

The activities, concentrated in three days, included collection of samples from the field, laboratory analyses and interpretation of the data. The project was planned and performed in collaboration with some researchers from local Universities, within the project PLS (Piano Lauree Scientifiche, a project within schools and universities to promote and support scientific degrees). The Department of Life and Environmental Sciences of the Polytechnic University of Marche collaborated for the biological experimental activities, while the Earth and Environmental Sciences Division of Camerino University ensured its cooperation for the development of geological subjects. The students were accompanied by their teachers and by instructors from the universities, both postgraduates and academics. The activities planned in collaboration with the university researchers involved other subjects, such as marine biology, stratigraphy and tectonic. The following sections will describe the work concerning the river environment.

Methodology

The activities performed from 3rd years students analysed different aspects of the Sentino River ecosystem, with a biological approach (Fig. 1). Each activity was performed after an introductory seminar run at school the day before.

Figure 1. Images of the Sentino River near Frasassi Gorge, where all the sampling took place.

The invisible inhabitants of the soil and river

Soil degradation is caused by many reasons which include excessive farming, construction, deforestation, salinization, solid waste. All these factors together, reduce soil fertility and water holding capacity. Soil indicators, such as edaphic microarthropods, respond sensitively to anthropogenic disturbance and their abundance and biodiversity are well correlated with soil health. Most edaphic animals have life cycles that are highly dependent on their immediate environment, interacting with soil in several different ways and adapt to it. Higher the number of microarthropods groups well adapted to soil is, the higher soil quality will be. Among several indices developed in the last years, QBS-ar (Soil Biological Quality arthropod) index evaluates, through the analysis of the biodiversity of soil edaphic microarthropods community, soil vulnerability. Each type of microarthropods found in the sample receive a score from 1 to 20 (eco- morphological index, EMI) according to its adaptation to soil environment. The QBS index comes from the sum of these scores. The higher score obtained, the better is the soil quality (Angelini et al., 2002).

The microarthropods from soil and macroinvertebrates from the river were collected on the first day of the investigation. The soil samples were collected by digging 1 dm^3 of soil with a small shovel and placed in a dark plastic bag to preserve the micro arthropods inside it (Fig. 2A). After that, the sample was processed at the lab where it was placed in a Berlese-Tullgren extractor which is a funnel with a sieve inside. The extractor was placed under a light source for 15 days. The microarthropods tend to escape from the light and take refuge at the bottom of the funnel and eventually fall into a becher containing a fixing solution composed of ethanol and glycerol (Fig. 2B). The microarthropods extracted were then ready to be analysed at the stereomicroscope. A sample of the preparation was therefore put in a petri dish and a sheet with a dichotomous key was delivered to each student in order to guide recognition and classification of the microarthropods (Fig. 2C, D, E). Once the recognition has been made, students calculated the QBS-ar index (Fig. 2F).

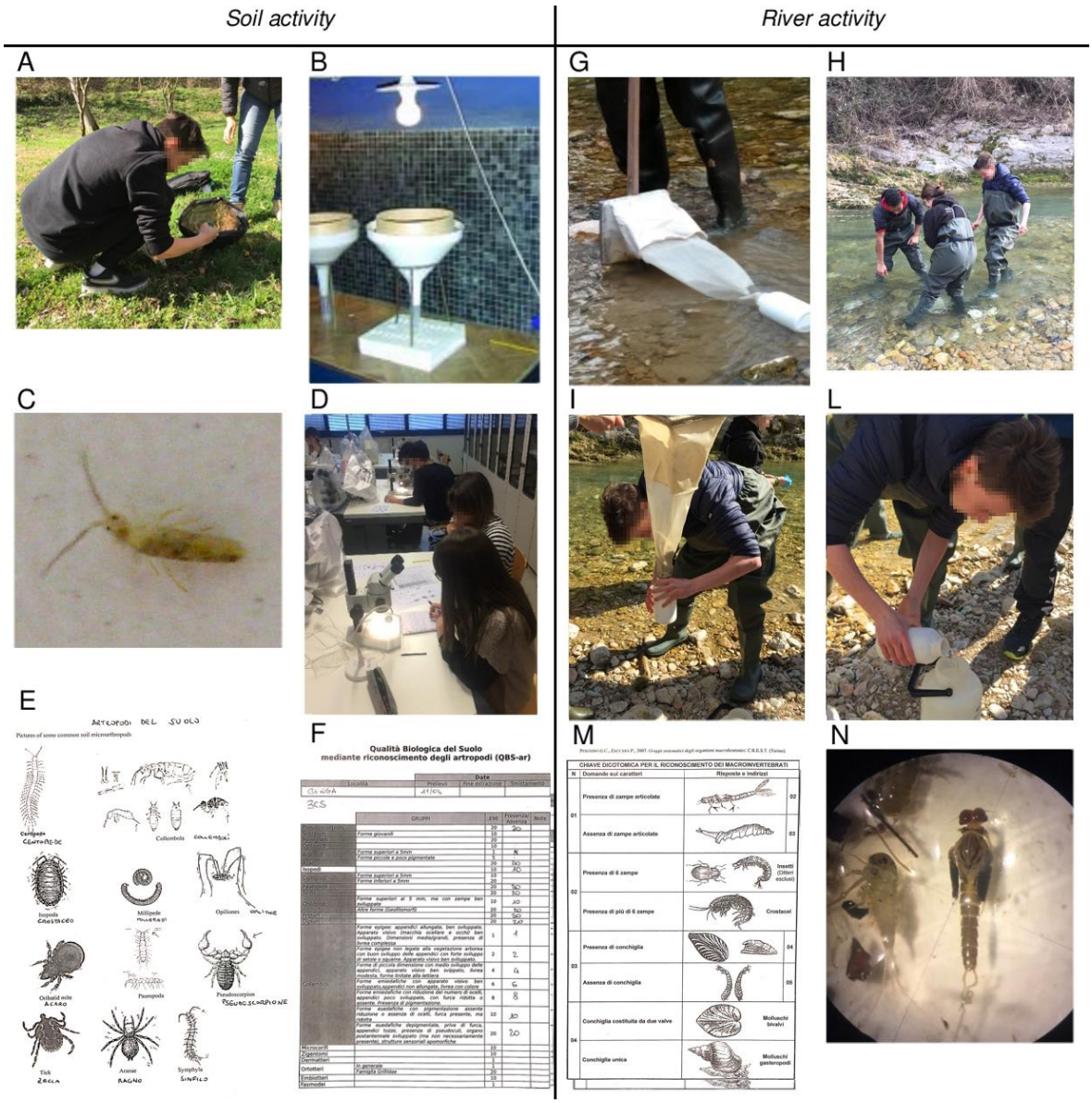

Figure 2. Soil microarthropods collection and analysis (A-F): sampling (A), preparation of the samples (B), analysis using stereomicroscopes (C,D), some material used to classify microarthropods and calculate QBS index (E,F). Analysis of macroinvertebrat

Macroinvertebrates are established and well known river bioindicators. The presence or absence of certain species indicates the state of health of the river, its degree of pollution and the anthropogenic impact over it. IBE index (Extended Biotic Index) has been used for many years as a tool to assess river health. In this project,

students didn't calculate the IBE in detail since the sampling and classification methods have become more complex with time and require high specialised operators (CNR, 2007). However, they learned how to collect a sample from the river and analysed at the stereomicroscope the different macroinvertebrates that populate the river. Samples were collected on the same day of soil sampling. Students went into the river and placed the macroinvertebrate sampling net against the river flow, while moving the pebbles at the bottom of the river with their feet to collect as many organisms as possible (Fig. 2G, H). The net is connected with a bottle, therefore all the macroinvertebrates ended up inside it. The bottle with live organisms was carried at the university laboratories and samples were processed to fix the macroinvertebrates (Fig. 2I, L). The fixation was made with a solution containing ethanol and glycerol. Once the sample was ready, students were able to take an aliquot of it, place into a petri dish and observe the organism at the stereomicroscope. Students have also tried to recognise the different taxa using dichotomous keys provided by the researchers (Fig. 2M, N).
Regarding freshwater microalgae, students observed the purification techniques used to isolate them. Sampling was carried out from a lake nearby the laboratories as it was not possible to collect samples from the river. In addition, they observed under the microscope some species of purified microalgae kept in culture from the university researchers.

Can we drink the river's water?
The chemical analysis of the river was completed during the fieldwork and continued at the university laboratories. On the first day, students took samples directly from the river where they also collected the temperature and salinity values (Fig. 3A). Once the samples for each student were collected, the pH of the water was measured (Fig. 3B). Further analyses were carried out at the university laboratories, where the hardness of the water was calculated by complexometric titration (Fig. 3D). Additional analyses were carried out looking for phosphates, nitrates and nitrites, which are contaminants present when the river is polluted. These analyses used spectrophotometry (Fig. 3C). In addition to the water collected directly from the river, other samples were also analysed in order to compare waters from different environments.

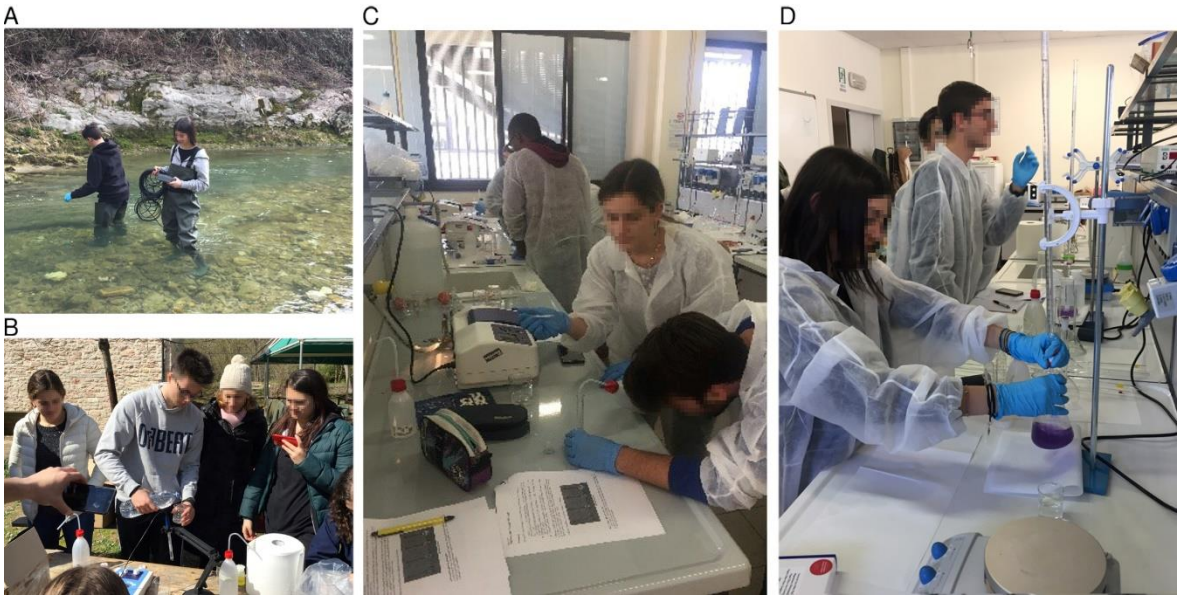

Figure 3. Sampling and chemical analysis of water. Water sampling and analysis performed in the Sentino River (A, B); analysis performed at the Università Politecnica delle Marche laboratories: spectrophotometry (C), and titration (D).

River chemistry and discharge
These activities were planned for 4rd years students, and focused on the influence of geology on the river chemistry and discharge. We chose the Potenza River valley, close to the Camerino University. In the area, the geology, groundwater circulation and river discharge are well known (Minetti et al., 1991) and a detailed informative booklet

on groundwater circulation and karst (Galdenzi, 2015) may help in providing scientifically correct but more easily accessible material for students.

Along the river, sampling points were located upstream and downstream of the Bagno Spring, near Fiuminata. This spring water rises mainly along the riverbed at the core of an anticline (Fig. 4). This water follows relatively deep circuits and is enriched in sulfates dissolved from underlying evaporitic rocks. This contribution of spring water is capable of modifying the chemistry of the river water, as can be revealed by conductivity measurements and chemical analyses, while the differences in discharge are less significant.

In the laboratories we chose to analyse only the most significant ions, in order to allow students to highlight the changes in the river water chemistry and familiarize with different methodologies, such as the colorimetric methods and spectrometry. During the elaboration of the data, the students are guided to locate sampling points along a schematic geological profile and evidence the relationships between groundwater circulation and river water characteristics.

The activities regarded a single class, divided in two groups during the field work, with the purpose of directly involving each student in the operative activities. Unfortunately, the effective actuation was not possible due to lockdown related to Covid.19. We intended to arrange the work on three days, with the following schedule:

Day 1 - In the morning, an introductory seminar at school introduces the subject and provides specific knowledge on the geological setting and on the methods of measurement and sampling. In the afternoon, a guided field trip to the nearby Frasassi Gorge aims to show the rocks characteristics and introduces the use of instruments.

Day 2 - This daytime is fully dedicated to the field work on the river. The students have to measure the river discharge with a hydraulic reel, execute measurements on the water parameters and sample water for chemical analysis.

Day 3 - In the morning the students work in the chemistry laboratory of the University to get some chemical parameters and elaborate the data of discharge. In the afternoon, the different data are organized and related to the geological setting of the area.

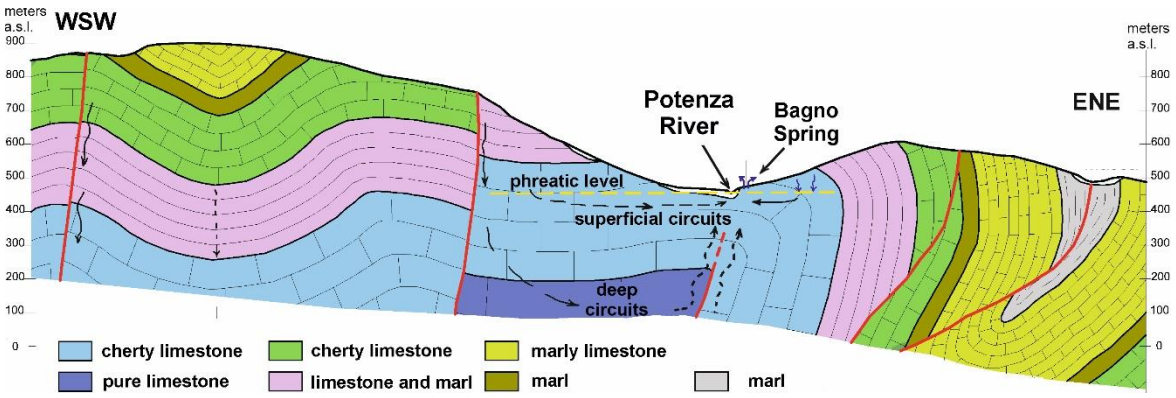

Figure 4: Geological profile through the Bagno spring, showing the presumed pathway of groundwater (after Galdenzi, 2015, simplified).

Results and Discussion

The activities carried out were inspiring for the students, who actively participated both in surveys on the ground and analysis of the collected material. The collection of data turned out to be exciting and particularly pleasing to some students, probably because it allowed them to enhance qualities such as spirit of initiative, resourcefulness, normally not used in “every day” school. However, participation was active also in the following moments, during the analysis and elaboration of the data, compiling tables, graphs and during the discussion of the results.

Of course, the results obtained during this work have no scientific relevance due to the simplification introduced and the uncertainty in the quality of the students' measurements and determinations. The didactic relevance of this type of work lies in applying the experimental method to a case study, verifying that any real knowledge about the environment, and, more generally in science, follows a systematic work based on collecting and processing experimental data, with conclusions that must stick to them and not be based on personal convictions.

Even if we are satisfied as teachers with the result obtained, we cannot hide the difficulties related with repeating this type of activity. Active student participation is essential, and this requires a positive vibe in the class. Based on the feedback from graduates and supporting academics, the active participation of the teachers who must not limit their role to that of chaperones, is also essential to obtain the full cooperation of students.
The students felt the activity as an extraordinary moment not only because it differs from the normal didactic activities, but also for the involvement of specialised personnel and for access to university laboratories. This experience confirmed that the river could be considered an open-air classroom, an ideal setting to investigate environmental processes.
However, extension of these activities to a greater number of students appears to be difficult to achieve. On a practical level, the organization came out against some difficulties, as the period had to be chosen based on the availability of the laboratories and teachers at the University, combined to the school calendar. That obliged to execute most activities in the winter period, which is not suitable for the soil fauna collection. Furthermore, the need to agree on dates and book workshops well in advance prevents the possibility of flooding in rivers from being taken into consideration, a condition that luckily did not occur during our fieldwork, but that could impede a large part of the field activities. For this reasons, we are considering, for the future, to reduce progressively our dependence from the University staff and laboratories, although this represents one of the greatest strengths of the whole project.

Acknowledgements

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AUSA RIVER: AN EXAMPLE OF SCHOOL AND RIVER INTERACTION

Coceano M.P.1, Mocellin G.2, Rigonat L.3, Zanon P.4

ISIS Bassa Friulana – Associazione GLOBE Italia1234, globeitaliasifd@gmail.com

Abstract

Rivers can arise in students the desire to increase their knowledge of this important feature of nature, but also of their environment. Often they are river users in many ways, so school can take advantage of their interest to promote a kind of teaching very effective and productive: experimental teaching. The example presented in this paper shows how the gathering of data and their elaboration and discussion, moves students to feel responsible toward the environment and the community - what is usually called active citizenship. Working together in practical activities outdoor in the field, produces a better integration between teachers and students and allows to construct together new paths of research. It also increases not only student competences but self-confidence as well. Moreover, students become aware to be able to have an impact on environment safeguard and to benefit community.

Keywords: Inquiry Based Learning, active citizenship, secondary schools, skills

Introduction

In this paper we describe an example of experimental learning and active citizenship that can also be an example of Inquiry Based Learning.

It was triggered by the presence of River Aussa in Cervignano, the town were our school is located. ISIS Bassa Friulana (previously ISIS Malignani Cervignano del Friuli) is a technical school with a Course of Chemistry.

Seeing the river crossing the town and the nearby country side, it is quite normal for students to ask themselves: how healthy are our river waters? How many pollutants are there in them?

Methodology

Chemistry course curriculum includes study of matrices in different physical states and water analysis is the fundamental part of 3rd class Analytical Chemistry curriculum. Instead of just teaching students how to perform them, and do it in a laboratory, the team of chemistry teachers agreed to work together in spurring students to ask themselves questions on the local environment, bending expected competencies to an environmental target, but keeping well routed scientific knowledge and methods. Measurements are done on the field, as you can see from fig.1, and students are the leading actors.

Figure1. Students sampling river Aussa.

As our school is a GLOBE school, we share GLOBE mission: to promote the teaching and learning of science, enhance environmental literacy and stewardship, and promote scientific discovery. We follow the scientific research process shown in the following picture:

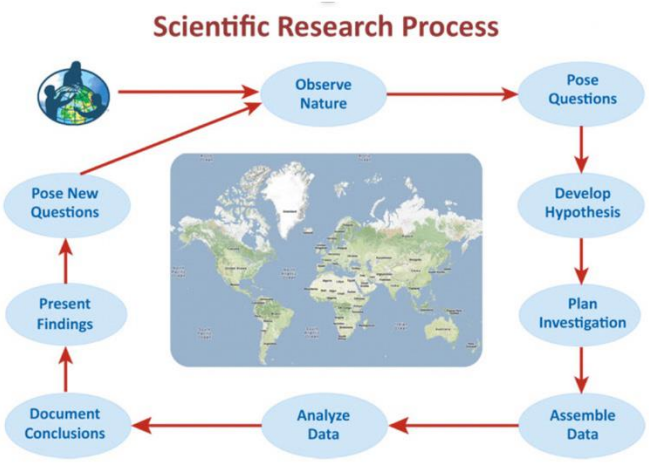

Figure 2. Scientific research process used in GLOBE.

Helping students to acquire citizenship competencies - meaning the ability to act as responsible citizens especially referred to environmental and sustainable development field - is included in school targets.

Investigation - first step

Starting from the question: what is the river water status? students of the 3rd class of chemistry performed measurements in different points of Aussa river, included in the middle of the town. They started from GLOBE protocols for water analysis on the field, but added to them more specific measurements, as our school is a technical one and has got many high performance instruments.

Among chemical and bacteriological parameters investigated, E.Coli and nitrates were above the limits requested to comply with European directive and Italian Laws regarding surface waters.

Active Citizenship –first step

Students had the chance to show their results to citizenships during an event called: Walk on the Aussa. They aroused the curiosity of people and this caused the analysis results to be published on a regional newspaper, amplifying the impact of the news. As a consequence, the Municipality asked the school to continue performing measurements.

Ambiente, monitoraggio affidato agli studenti di tre istituti superiori

Cervignano: coinvolti Malignani, liceo e Brignoli di Gradisca
L'idea è quella di creare una struttura permanente

di Erica Michellut

CERVIGNANO

Una struttura permanente e indipendente per il monitoraggio dell'ambiente, in particolare della qualità delle acque, gestita dai ragazzi degli istituti superiori cervignanesi. Servirà, nell'ottica della continuità, ad avere dati aggiornati in merito alle condizioni ambientali della cittadina friulana. Il Comune di Cervignano, che ha lanciato la proposta, sta pensando anche a una convenzione di sigla-re con le scuole. L'assessore comunale all'ambiente, Ivan Snidero, è intenzionato a procedere in questa direzione. «Qualche giorno fa - fa sapere Snidero - è stata organizzata, proprio a Cervignano, una 3 giorni di approfondimento sulle tecniche di monitoraggio ambientale e sul telerilevamento. L'iniziativa, che ha interessato 23 studenti, era rivolta ai ragazzi più meritevoli del triennio delle scuole superiori. Sono stati coinvolti gli alunni dell'Iti Malignani e del liceo di Cervignano e gli studenti dell'Iss Brignoli di Gradisca d'Isonzo. I docenti hanno spiegato le modalità di rilevamento dei dati sul campo. I professori si sono soffermati soprattutto sul monitoraggio dei vari habitat che caratterizzano il nostro territorio e sui corsi d'acqua superficiali.

Figure 3. Article on regional newspaper.

Investigation - second step

Students were very happy to move a step forward preparing a new project in order to continue analysis with the purpose to find out the reason of this limits exceeding.

The idea was to sample the river in different points, starting from the spring and continuing till beyond the town center. In the following picture you can see the map of the sample sites and a very pleasant way of sampling.

Figure 4. Sampling

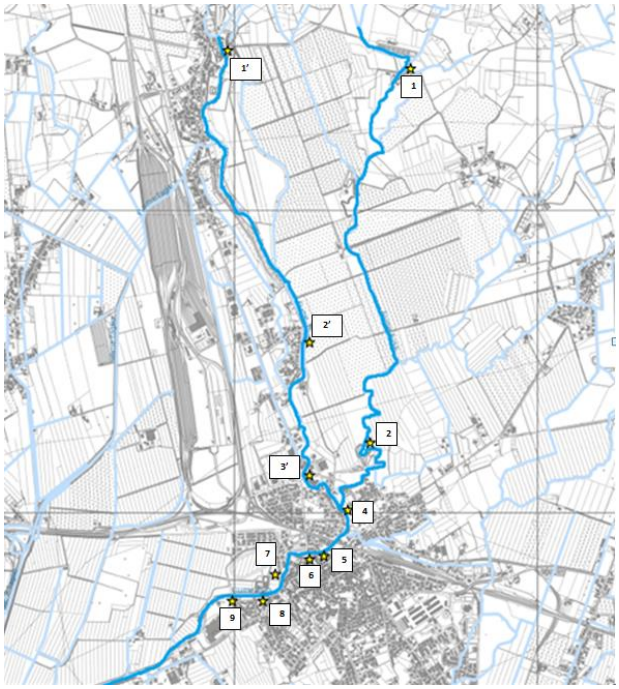

Figure 5. Sampling Sites

The samples were analyzed, data were elaborated and an interlaboratory test was performed confronting students results with the ones of a private laboratory.

Figure 6. Student in a private laboratory and in school laboratory

Table 1. Example of data: site 5

Site 5: Cervignano city center	45° 49' 26,6" N 13° 20' 06,5" E					
	05.11.2015	21.01.2016	27.07.2016	09.09.2016	17.11.2016	27.01.2017
pH	7,73	7,89	7,74	7,60	7,76	7,90
Conductivity (µS/cm)	501	462	482	440	426	362
Nitrates (mg/L)	20,8	19,8	20,0	19,7	20,5	20,9
E. Coli (UFC/100 mL)	3200	2800	2200	2800	3800	3700

Results

The more important results of the campaign are the following:

- Nitrates concentration changes with season
- Nitrates concentration decreases along the river due to phytodepuration phenomena
- Microbiological analysis allow to evaluate the impact of town on river, due to the fact that not all houses are connected to sewage system and therefore discharge directly into the river.
- Microbiological analysis data were validated by confronting them with the ones of the accredited laboratory G.A.I.A. Nitrates values instead resulted underestimated by 14%, but their trend was confirmed.

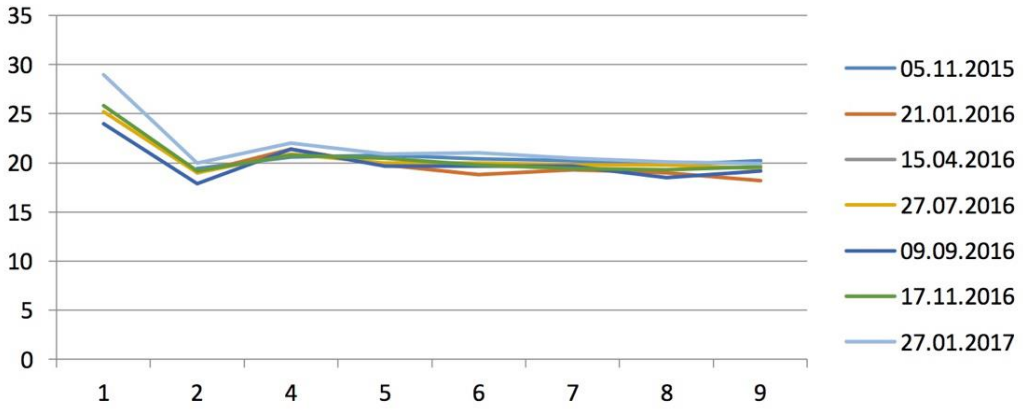

Figure 7. Nitrates - river Ausa

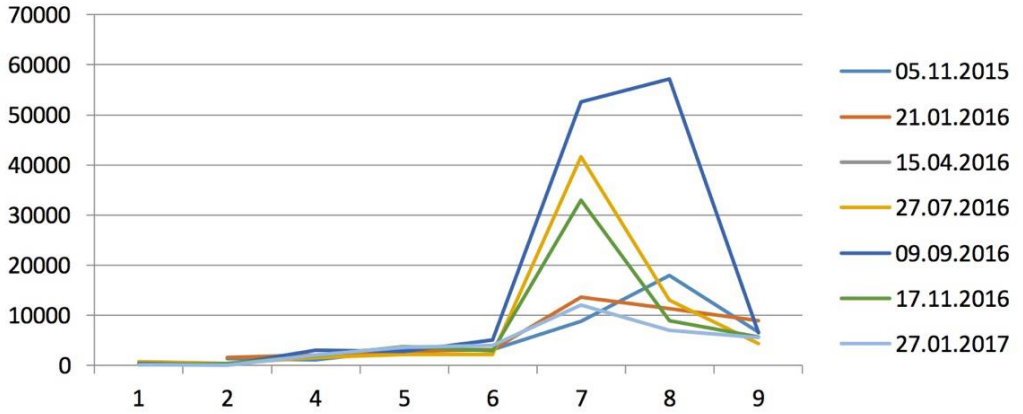

Figure 8. Escherichia coli - river Ausa

Active Citizenship –second step

Students asked themselves: What further actions can be made now to improve the situation?

Data regarding E.Coli have been already presented to citizenship in a few occasions. Municipality has planned to connect to the sewage system many more houses avoiding direct discharge into the river.

A natural continuation of the project could be to go on analyzing river Aussa waters and compare new data with the previous ones to check the efficacy of new wastewater system.

The initial part of the project was presented at the GLOBE Virtual International Science Symposium in 2017 and, among the other badges, it received the special one “make an impact”, recognizing its value in benefiting the community (Fig. 10). The complete paper is available on GLOBE web site.

Figure 9. IVSS project presentation in GLOBE web site.

Figure 10. Students' presentation to the public and stakeholders.

Discussion and conclusion

In last times interest in environmental issues is increasing more and more and schools can be a point of reference for data gathering to integrate research or protection agencies activities. Rivers are very important objects of study because of their strong relation with towns and people as well as with ecosystems. Having a river nearby is very useful for schools because it is an outdoor laboratory. The experience mentioned in the paper is an example of this. From a scientific viewpoint this way of learning helps students to understand what is required by a scientific research by planning it and to get in touch with accredited partners, enriching their experience. From an educational point of view, becomes a privileged path for the acquisition of fundamental skills in scientific, professionalizing and citizenship skills. By tackling an environmental problem as well as a natural, historical or heritage aspect with a scientific approach, cognitive and methodological skills and abilities are developed that favor the understanding of reality and the ability to move consciously in it. Our students were engaged in a challenge and had to answer by means of investigation that required the recognition of critical issues and the proposal of possible solutions. This working method contributes to the formation of critical thinking and stimulate students to propose different solutions and to choose strategies among them. In this way their capacity to assume autonomous responsibilities is increased, contributing to the construction of a personal way to face life.

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www.globe.gov
www.globeitalia.it

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EDUCATION ENHANCEMENT IN CULTURAL, ARTISTIC AND LANDSCAPE HERITAGE OF A WETLAND

Zampella R.[1], Antoi M.[1], Baglione M.[1], Battaglia Masini J.[1], Cerri A.[1], Ibellani A.[1], Mori V.[1], Migliorini A.P. [1], Ugolini F.[2]

[1]*Liceo Coluccio Salutati, Montecatini Terme, Italy*
[2]*Istitute of BioEconomy – National Research Council, Sesto Fiorentino, Italy, francesca.ugolini@ibe.cnr.it*

Abstract

In 2018, the high school Lyceum Salutati in Montecatini (Tuscany) implemented the project "*Education enhancement in cultural, artistic and landscape heritage"* funded by the National Operative Program "For the School" 2014-2020. The project aimed at raising awareness on the importance of the local cultural heritage and at promoting the natural protected area of the Fucecchio wetland for its environmental and cultural importance, being the biggest inner wetland in Italy, protected under the EU Birds Directive 79/409 and Ramsar convention.
The project was an extra-curriculum activity organized in three modules and was implemented by three classes of 15 students: Module 1 was on the development of a Location Based Game (LBG) to know and promote the Fucecchio wetland; Module 2 was about the assessment of the people's perception on Cultural Ecosystem Services of Fucecchio wetland and Module 3 promoted and increased students' skills on waiving the wetland grasses as traditional activity especially until mid-1900.
The project allowed students to explore aspects of their territory that were probably unknown or partially known. It gave them the opportunity to develop manual skills, technological skills, communication skills and apply scientific method all in relation to the knowledge of the local cultural heritage.
We are hopeful that all these experienced increased the students' sensitiveness toward the place where they live and their awareness about the importance to communicate these values to the public.

Keywords: cultural heritage, hands-on, landscape, students, technological skills.

Introduction

In order to build full citizenship, it is essential to sensitize students to their cultural, artistic and landscape heritage with the aim of educating them to its protection and transferring them its value for the community. It is also important to promote the landscape as common heritage enhancing the sense of belonging to a specific place, and generating potentially democratic belief and development.
The cultural heritage that is connected to the landscape and its people, is defined by the Faro Convention (Council of Europe, 2005) as [Art. 2] *a group of resources inherited from the past which people identify, independently of ownership, as a reflection and expression of their constantly evolving values, beliefs, knowledge and traditions. It includes all aspects of the environment resulting from the interaction between people and places through time.* In addition, the definition includes also the community perspective, as *the heritage community consists of people who value specific aspects of cultural heritage which they wish, within the framework of public action, to sustain and transmit to future generations.*
Therefore, cultural heritage constitutes a shared source of remembrance, understanding, identity, cohesion and creativity.
Furthermore, it is also enhancing the knowledge of cultural heritage that citizens' right to participate in cultural life is guaranteed, as indicated in the United Nations Universal Declaration of Human Rights (1948) and citizens can raise such awareness. Educational initiatives that aim to promote knowledge of national heritage encourage the development of culture. The Faro Convention or the Council of Europe Framework Convention on the Value of Cultural Heritage for Society was ratified in Italy in 2013 and claims that knowledge and access to heritage are

right for citizens to participate in cultural life. Cultural heritage is a source for human development, enhancement of cultural diversity and promotion of intercultural dialogue, and a model of economic development based on the principle of sustainable use of resources.
The importance of the promotion and awareness of cultural heritage was the main theme of the project "*Education enhancement in cultural, artistic and landscape heritage"* funded by the National Operative Program "For the School" 2014-2020 and implemented at the high school Lyceum Salutati in Montecatini (Tuscany) in 2018.
The cultural heritage object of the project was represented by a natural area of the local territory. A few kilometers far from Montecatini, the Fucecchio wetland represents the biggest inner wetland in Italy, protected under the EU Birds Directive 79/409 and Ramsar convention. It counts hundreds of migratory and stationary species although the protected part is geographically split in two smaller areas inside the wetland.
From the historical point of view, the area has been exploited since the renaissance time and over the centuries has undergone continuous transformations, such as lake formation and land reclamations but it has also faced environmental threats like hunting, alien species, water pollution.
However, the area is also important for historical events such as the tragic massacre of civilians occurred during the II World War described as "one of the worst Nazi atrocities in Italy" (ANSA, 2018) (Fig. 1), traditions (waiving activities with the grasses of the wetland) and recreation (tourism, birdwatching, sport).

Figure 1. Monument to the massacre of civilians occurred during the II World War.

The aim of the project was to develop transversal skills with particular attention to those aimed at spreading the business culture by improving key competences, but also to promote equal access to good quality secondary education, including formal, non-formal and informal learning paths.

Methodology

The project was structured in three modules on cultural heritage regarding the Fucecchio wetland:
Module 1: Location Based Games (LBG) to know and promote the Fucecchio wetland.
This module aimed at enhancing the access, exploration and knowledge of the knowledge of the area using digital tools, in the specific, Apps and software for the development of a geo-localized game to be played on mobile devices.
Module 2: Cultural Ecosystem Services of Fucecchio wetland (Ugolini et al. 2020) and the Nievole Valley.
This module aimed at building up a proposal for a sustainable cultural, social and environmental tourism in the local valley and at performing an evaluation of the cultural ecosystem services perceived by citizens linked to the Fucecchio wetland.
Module 3: Waiving.

This module aimed at increasing the awareness and skills on artistic and cultural products made of natural resources from the wetland (e.g. wetland grasses). This module is based on the several economic and cultural activities that were common until the first half of the XX century and today are only in elders' memory.

Each project module was implemented by one class of 15 students (age of 16) as extra-curriculum project, and had a duration of 30 hours, organized in three-hour meeting a week, in the afternoon, for 10 weeks.
The classes were held by experts in the field of the module who were supported by tutor-teachers.
The project fostered the collaboration and the establishment of a network with the local organizations, associations and academic institution, and local authorities.
The methodological approach fostered:

- access, exploration and digital knowledge of the heritage;
- adoption of parts of heritage (products, traditions and waiving methods);
- sustainable cultural, social and environmental tourism;
- knowledge and communication of the local heritage;
- digital tools;
- artistic and cultural production;
- interdisciplinary learning and complementarity between thematic areas and school subjects
- Experiential learning with practical activities and experiences in the classroom and outside.

Results

Module 1 aimed at Increasing the environmental awareness and knowledge towards the environment through the development of a LBG as a tool to promote the Fucecchio wetland.

Students, teachers and facilitators (environmental guides, ICT experts), as part of a team, were committed to follow a learning process focused on nature protection and structured in four steps:

1) Collection of stories and information on the protected area of the Fucecchio wetland in autonomy and during guided tours at the protected area (Fig. 2).

Figure 2. Students field visit at the protected area of the Fucecchio wetland.

2) From the knowledge acquired, definition of a fantasy story (storytelling) that will be the bases of the LBG. Mission, actions and scores/gains are established together with the characters and how they interact with the player of the Location Based Game.
3) Training and development of the Location Based Game on the ARIS platform (Fig. 3). The game can be played at the wetland (and anywhere), just by using Arisgames App and searching the game: *Lino e Gagge al Padule di Fucecchio.*

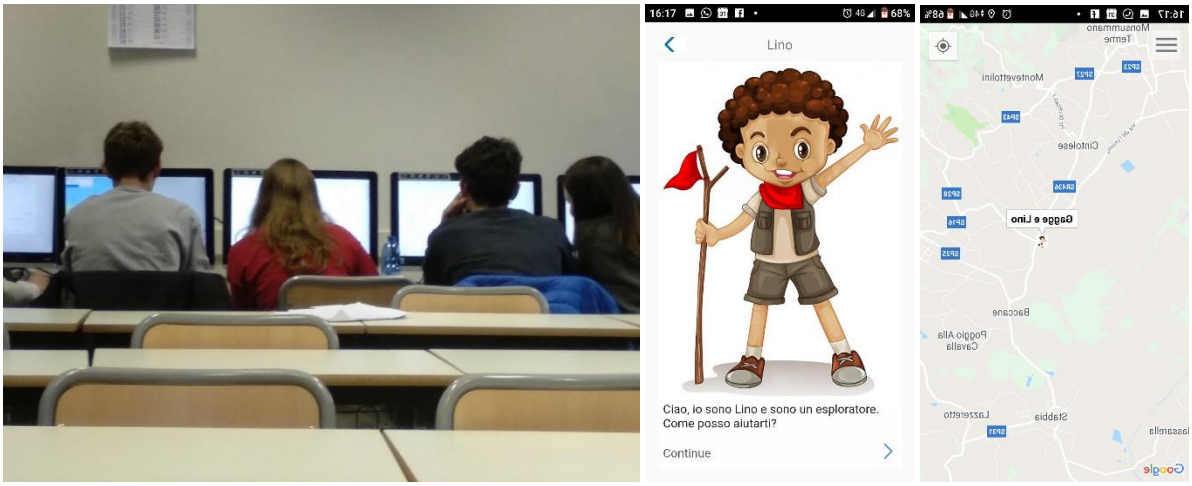

Figure 3. Students developed a LBG to be played at the protected area of the Fucecchio wetland.

4) Presentation of the outcome to the public.
In a final event organized at the visitor center of the Fucecchio wetland, students presented all the steps of the module and the final game to the public.

Module 2 aimed at increasing the awareness of the importance of the Fucecchio wetland for the local community, through the evaluation of the perception of the cultural ecosystem services. Within the module, students, guided by the experts, set up and carried out a survey through a questionnaire to identify the extent of cultural identity, aesthetic and recreational values for the people. The activity was organized in four steps:

1) Assessment of the Fucecchio wetland promotion on the web through www.answerthepublic.com (Fig. 4)
2) Creation of a questionnaire to be submitted to a population sample of the province of Pistoia for the evaluation of their opinion on cultural ecosystem services.

Figure 4. Students produced a word-cloud obtained by the analysis of words connected to Fucecchio wetland on the web based on Google search engine.

3) Data collection with a representative sample of the population of the province of Pistoia, data analysis with the presentation of results (Fig. 5).

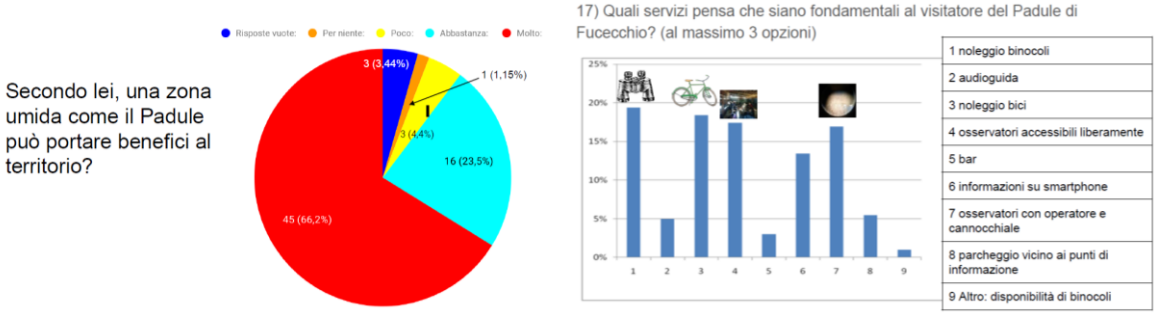

Figure 5. Example of analysis and results about the extent of benefits provided by a wetland as perceived by people and the services that people would suggest to improve for visiting the wetland.

4) Discussion of the results and proposition of tourism routes in front of the public in a public event organized at the visitor center of the Fucecchio wetland.

In module 3 “Waiving” students had an immersive activity with practical activity on traditional waiving and knowledge. The physical and naturalistic characteristics of the wetland were described during a field visit guided by the local organization (CRDP Padule di Fucecchio) and then the attention was focused on the traditional grasses that have been used for centuries in waiving (Tufted Sedge, Carex elata L.) (Figure 2).

Figure 2. The typical tufted sedge (Carex elata L.) ready to be waived.

A traditional craft-maker showed them how the grasses are cut and then students made practical laboratories waiving some dried leaves into bags and other products (Figure 3).

Figure 3. Waiving experience made by the students.

Then, students produced digital and creative materials (video, posters with QR codes) to promote and transfer the acquired knowledge. These products were presented in an exhibition at the visitor center of the Fucecchio wetland (Figure 4).

Figure 4. Products made by the students.

Discussion and conclusions

The project allowed students to explore aspects of their territory that were probably unknown or partially known. It gave them the opportunity to develop manual skills, technological skills, communication skills and apply scientific method all in relation to the knowledge of the local cultural heritage, in collaboration with different kinds of experts. The project included different kinds of methodological approaches: from theoretical presentations with brainstorming, field-visits, hand-on activities and group work. It also allowed students to experience different technological tools and software that are not commonly used in the school curriculum.

On this regard, students could work on innovative platforms for the i) development of Location Based Games, ii) extrapolation of web contents, iii) creation of word clouds, iv) creation of survey tools; v) data analysis on

worksheet; vi) creation of PowerPoint presentation; vii) video making. In addition, as all the projects' outcomes were shared in a common work place (namely Google Drive), the students increased also the sense of responsibility in group-work as one's action (even a small mistake) could affect the whole group's work.
The possibility to present the final results in front of the public at the visitor centre of the CRPD, allowed students to experience their communication skills, verifying own understanding, reinforcing their knowledge and probably raising satisfaction and self-esteem.

We are hopeful that all these experienced increased the students' sensitiveness toward the place where they live and their awareness about the importance to communicate these values to the public.

Acknowledgements

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ASSESSING THE CITIZENS' PERCEPTION OF CULTURAL ECOSYSTEM SERVICES OF A WETLAND

Ugolini F.[1], Baglione M.[2], Battaglia Masini J.[2], Migliorini A.P. [2], Zampella R.[2]

[1]Institute of BioEconomy – National Research Council, Sesto Fiorentino, Italy, francesca.ugolini@ibe.cnr.it
[2]Liceo Coluccio Salutati, Montecatini Terme, Italy

Abstract

In recent years the concept of "ecosystem services" (ES) has been widely investigated and promoted. ES represent the benefits that ecosystems provide to the community due to different functions of the natural components (e.g. primary production, carbon stock, water and pollutant regulation, biodiversity) but also the cultural services (cultural value, attachment, recreational services) that are linked to such ecosystems. Wetlands are water ecosystems that provide a large variety of services. The "Padule di Fucecchio" in Tuscany, is the biggest Italian inner wetland and represents an important place for migratory birds to feed and nest. In the past, its natural resources (e.g. fish, birds and grasses) were sustainably exploited by the local population to get food and produce ordinary objects by waiving, while nowadays most part of the area is a private hunting reserve and only 10% surface is protected as CIS of Natura2000 network. Moreover, the area is historically known for the Nazi retaliation during the IIWW, thus it is often remembered for this cruel event.

The objective of this study was to assess people perception about the importance of the area for cultural and recreational purposes and assess their opinion about the extent of actual promotion.

The study was performed by the students of the high school Scientific Lyceum Coluccio Salutati, located in the town of Montecatini, the biggest town near the wetland, who developed an online questionnaire that was used to survey local people. 70 responses were collected in three weeks.

The results show that respondents are aware about the natural richness of the wetland, and about its importance for recreational purposes. More than 50% visited the protected area for recreational purposes prior the survey and 66% participated in the activities offered by the managers of the protected area.

The majority think that the wetland is more important for recreational rather than productive activities and that its protection is very important. They also suggested tourism services such as renting binoculars and bikes and presence of a professional operator at the birdwatching observatory.

Keywords: cultural ecosystem services, protected areas, survey, tourism.

Introduction

Ecosystems are communities of organisms that live in balance in a certain environment, so that the biological and the abiotic components are linked together, interacting through the element cycles. Ecosystems provide services to the community of human beings, for instance the most famous is the provision of primary products such as food, timber, oxygen by plants. Ecosystems support life, biodiversity and regulate the element cycles (water, carbon, nitrogen) and buffer pollutants, besides improving directly and indirectly the quality of our life.

WWF Living Planet Report (2016) provides a very clear picture of the services and benefits provided by ecosystems, that in general can be summarized in four categories as established by TEEB (2010).

- **Provisioning services:** provision of products such as food, fresh water, wood, fiber, genetic resources and medicines.
- **Regulating services:** regulation of ecosystem processes such as climate regulation, natural hazard regulation, water purification and waste management, pollination or pest control.

- **Habitat services:** provision of habitat for migratory species, and for maintaining the viability of gene-pools.
- **Cultural services:** non-material benefits that people obtain from ecosystems such as spiritual enrichment, intellectual development, recreation and aesthetic values.

Cultural ecosystem services (CES) are less investigated in comparison to other services but they are also important, especially because most people live in urban contexts and increasingly need contact with nature. The physical, emotional and mental advantages produced by ecosystems are often intuitive and implicit but the value attributed to them depends on the individual and cultural assessments of their contribution to well-being, although they are rarely reflected by economic indicators and are rarely marketable.
Among CES, recreation, tourist and aesthetic values are more explored (Milcu et al., 2013) than others such as spiritual, educational or cultural heritage values which are especially important for the identity value and the personal attachment.
The “Padule di Fucecchio” is the biggest Italian inner wetland, located in Tuscany in between Appennine foothills on the North-West side, and hill chains between the provinces of Pistoia and Florence.
The whole wetland is about 1800 hectares wide and its natural function is water collection from several streams originating in the Appennine mountains and hills and its regulation.
The area is an important feeding station for birds during their migration to the northern latitudes in Europe, allowing migratory species to feed and leave or to remain and nest, besides counting many stationary bird species. The protected part is a Natura2000 site (EU Birds Directive 79/409) listed under the Ramsar convention, although the protected area is geographically split in two smaller areas. The scientific consulting for the wetland management and promotion initiatives are carried out by the Centre for Research, Documentation and Promotion (CRPD).
Water regulation and management has changed over the centuries but it attracted interest. For instance, dating back to the renaissance period, Cosimo dei Medici - ruler of Florence, ordered the creation of a big lake to provide the noble families’ tables with heels and other fish. Leonardo da Vinci in 1503 designed a project of an artificial canal - though never implemented, to connect Florence to the area. A couple of centuries later (second half of the 18th century), as the sediments filled in a vast area of the wetland, under the Lorrain’s Grand duchy, the water flow was restored and draining canals were creates, besides reclamations to make the land productive and reduce the risk of malaria. The last reclamations date back to the 80s’ of the XX century.
The typical formations of the wetland are small lakes called “chiari” (clear) where birds area attracted by artificial decoys, surrounded by weeds (Phragmites australis L.) where hunters hide.
Nowadays, most part of the wetland is a set of private hunting reserves among which, two distant small areas of 100 ha each - representing together 10% of the total wetland, are protected. The area “Morette” can be freely observed from the birdwatching observatory located along a dirt road at the margin of the wetland, while the other one, Righetti, has a stricter protection level being a natural reserve, only accessible by guided tours. This area is richer in biodiversity as it hosts also a riparian vegetation with tall indigenous trees and other typical grasses.
The “Padule di Fucecchio” is also sadly known for the massacre occurred during the II World War, that has been described as "one of the worst Nazi atrocities in Italy" (ANSA, 2018).
As the dichotomy protection vs. hunt is one of the main environmental threats, linked to the local cultural traditions and habits and generations, this study aimed at investigating the actual perception of the local people regarding the wetland and its potential in tourism and recreational purposes. This was performed through an analysis of the people perception regarding some CES that could elucidate policy and decision making of the area for a sustainable development.

Methodology

In 2019, 20 students (class IIIB) in the age of 16 of the school Liceo Scientifico Coluccio Salutati (Montecatini, PT) were involved in the extra-curriculum project “A proposal for cultural tourism” funded by the European Union (FSE-PON 2014-2020, “PON - ASL “Potenziamento dell'educazione al patrimonio culturale, artistico, paesaggistico”). The project involved also the local organization CRPD and an expert from the National Council

of Research – Institute of Bioeconomy. The project aimed at raising students' awareness on the natural value of the local wetland, Padule di Fucecchio, by introducing the concept of ecosystem services and developing and implementing a scientific method to assess the general opinion on cultural ecosystem services (CES). In fact, the project objective was to assess people perception about the importance of the area for cultural and recreational purposes and their opinion about the extent of actual promotion. The project lasted 15 hours organized in five 3 hour-meetings. The project was leaded by the external expert and two school teachers supported the expert and provided the logistics. The first meeting aimed at introducing the participants and the purpose of the project. Brainstorming between participants produced a list of services and benefits connected to wetland ecosystems, so that the concept of ecosystem services (ES) and theoretical background could be given. Focusing the attention on the cultural aspects, an initial investigation aimed at understanding how the Padule di Fucecchio is promoted on the web. The students investigated how/what internet reports about the wetland by using the platform www.answerthepublic.com. This platform allows to extrapolate the words and concepts connected to a specific query.

The list of words extrapolated from the web, were then elaborated by using a word-cloud tool in order to graphically represent the word frequency.

In order to reach the objective of the study (assessing the public opinion on the importance of the wetland for recreational and cultural services), a specific survey was developed addressed to citizens and visitors of the wetland. The survey tool was a questionnaire with open-ended questions. Students got some guidance for building up the questionnaire, following basic rules for the definition of clear questions and answers.

Then, students identified three main topics to investigate:

- Knowledge and experience about the wetland
- Perception of the wetland
- People suggestions for its visitation and promotion, and willingness to pay

For each topic, students formulated a series of questions that were piloted within the group and corrected to provide the final version.

The final questionnaire included 27 questions (including those on personal details), most multiple choice and it was built in a Google-survey form. The questionnaire was anonymous and disseminated through social media, mailing lists and face to face interviews from the 27th of March to the 4th of April 2018.

The answers were screened in order to remove not reliable answers (with empty fields or when the personal details were not reliable). Then, data were elaborated in terms of frequencies and percentages.

Results and discussion

Web-analysis of Fucecchio wetland

The application of the query "Padule di Fucecchio" in the platform www.answerthepublic.com, resulted words' extrapolation from Google that can be organized in three main information groups: *how to access* the area (e.g. visiting hours, how to get there, what to see, maps), *information about environment and history* (fauna, flora, massacre) and *activities that can be performed* in the area (events, guided tours, hiking, hunting, etc.) (Figure 1).

The use of extrapolated words in a word-cloud app, resulted that "visite guidate"(guided visits) and "consorzio di bonifica" (consortium for land reclamation) which is the actual water manager of the whole basin were the most frequent words in the cloud. Other words resulted "strage" (massacre), "riserva" (reserve), "ponte" (bridge), "uccelli" (birds) etc. (Figure 2).

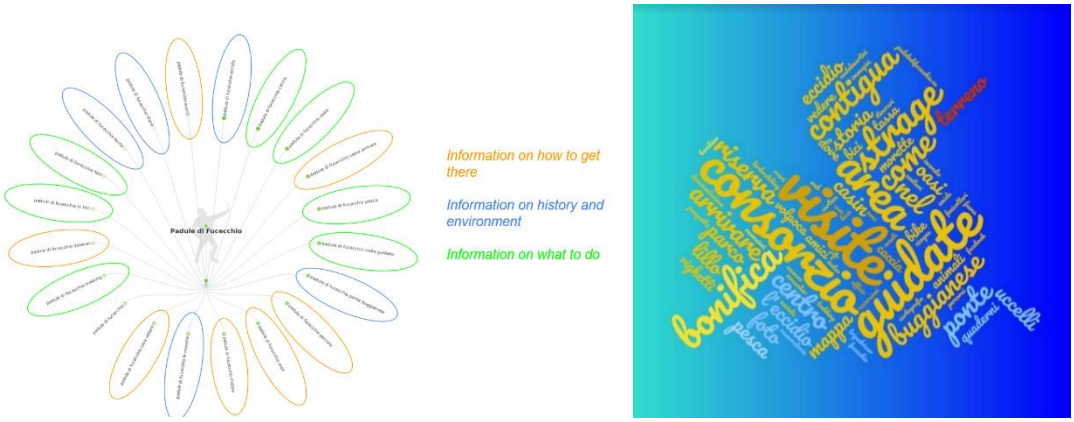

Figure 1. Content typology regarding the query “Padule di Fucecchio” for extrapolating words from Google by using www.answerthepublic.com (left) and representation of the words’ frequency in a word-cloud (right)

Results from the questionnaire

From the online survey and direct interviews, 68 valid answers were collected, 41 from females and 25 from males mostly living in the municipalities near the wetland, although some respondents were also from Florence and Prato. The most representative age class (60%) was between 36 and 65 years old.

Background knowledge

The overall knowledge of the area by respondents was rather good. 99% respondents declared to have heard about Fucecchio wetland.

Asking some specific questions about the environment and history of the area, 50% knew that the wetland surface has decreased over the years and 53% knew that it counts more than 200 species of birds. 62% respondents knew that the wetland is the biggest inner wetland in Italy and hosts species that are under risk of extinction.

In addition, 85% were aware of the terrible massacre by Nazi troops occurred at the end of the second world war, as the marble memorial witnesses the atrocity.

Only 32% respondents actually knew that the right size of the protected surface is only 10% the whole wetland.

Table 1. Respondents’ knowledge about the area.

Do you know that...	% respondents (N=68)
Fucecchio wetland is an important wetland	76%
The surface of the Fucecchio wetland has decreased over the years	50%
Fucecchio wetland counts more than 200 bird species	53%
Fucecchio wetland is the widest inner wetland in Italy	62%
Fucecchio wetland counts species at risk of extinction	63%
Fucecchio wetland hosted a cruel massacre in the II WW	86%

Frequentation

On average, respondents declared to visit Fucecchio wetland: 10% respondents did it very often, 32% rather often and 24% sometimes. 17% rarely visited the area while 13% never went there (4% did not answer).

In the year prior the survey, 69% respondents declared to have visited the wetland and the reason to visit was mostly for recreational activities such as biking/walking (28%), birdwatching/photography (13%), tourism (6%) while educational and research activities (12%) and work purposes (3%) were less selected. 7% did not give explanation.

The way the visitors went to the wetland was mostly on foot (49%) and by bike (7%) as they declared to walk on the main pedestrian path that crosses the beautiful woodland and reaches the birdwatching observatory, and by car (25%) when they went to visit the natural protected reserve (explained by the fact that it is not connected to the main pedestrian path) (8% did not answer).

Participation in promotion activities

70% respondents were aware of the activities (seminars, excursions, birdwatching, fairs) organised and promoted by the CRDP, 5% of which participated more than once a month, 32% at least once a month and 33% more than once in the year. In contrast, 30% never participated in activities promoted by the Centre.

Respondents' perception of the wetland

The questionnaire asked respondents the perception about the promotion of the Padule di Fucecchio. Only 3% selected the two extremes: not well promoted (3%) and well promoted (3%). The majority (60%) declared that it was little promoted and 32% rather much, while 2% did not give opinion.

Regarding the perceived importance of a wetland (in general) (figure 2), respondents consider it very important for attracting animals and providing them a suitable place. At lesser extent, they agreed on the importance for offering tourist services, practicing birdwatching, doing physical exercise (biking, walking) and attracting tourists. Less important were considered productive activities connected to a wetland such as hunting, fishing or typical art crafts with natural resources (e.g. waiving with grasses).

However, 96% agreed on the importance to protect the Fucecchio wetland. Respondents were also asked if they would visit the Padule di Fucecchio if they came from farther distances: 66% agreed, 22% did not know and 12% did not agree.

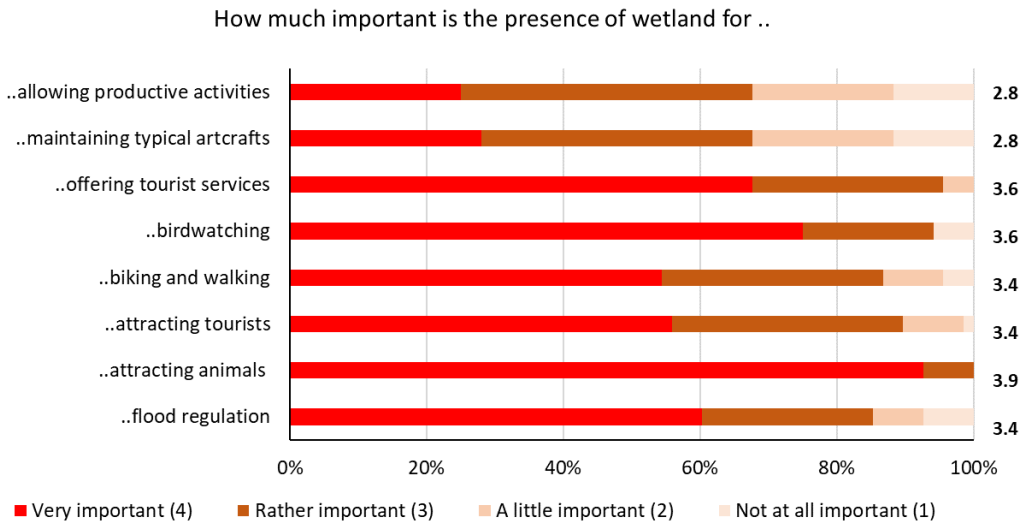

Figure 2. Importance of a wetland. The numbers at the right represent the weighted averages based on the of the values of the Likert scale options.

People suggestions and willingness to pay

Respondents were asked what services they would consider important for tourism purposes (table 2). The most selected were "Bike renting" (20% responses), "Freely accessible birdwatching observatories" and "Birdwatching observatories accessible with an expert equipped with binoculars" (both 19% responses). Also, "Information on smartphone" was suggested (14% responses) as well as "Binocular renting" (13%).

Table 2. Suggestions by respondents to improve the tourist offer

Suggestion	% of responses
Bike renting	20%
Freely accessible birdwatching observatories	19%
Birdwatching observatories accessible with an expert equipped with binoculars	19%
Information on smartphone	14%
Binocular renting	13%
Parking lots near the birdwatching observatories	7%
Audio-guide	5%
Bar	3%
Total	100% (N=189)

Surprisingly, the majority of respondents expressed the willingness to pay (table 3) for visiting the area a symbolic amount of money (up to 5€), although 15% were willing to pay more than 10€.

Table 3. Willingness to pay expressed by respondents.

Would you be willing to pay to visit Fucecchio wetland?	
No	19%
1-3€	25%
3.01-5€	24%
5.01-7€	10%
7.01-10€	7%
>10.01€	15%
	100% (N=68)

Conclusions

The project represented a scientific relevance for the students who could explore aspects of their territory that have never been made before in such context. It gave them the opportunity to apply scientific methods for social studies and to deal with concepts connected to the ecosystem services of a wetland.

The project included different kinds of activities and methodological approaches: from theoretical presentations with brainstorming to field-visits and group work. It also allowed students to experience different technological tools that are not common in the school curriculum. On this regard, students could work on innovative platforms for the i) extrapolation of web contents, ii) creation of word clouds, ii) creation of survey tools; iii) data analysis on worksheet; iv) creation of PowerPoint presentation.

The use of a common shared repository and work place (Google Drive) increased the sense of responsibility towards the other members of the group, to reach a common and shared result. Students could experience how one's mistake could affect the whole team's work and how keeping the pace of work is important to accomplish the tasks within the established deadlines.

The final results were presented in a public event at the visitor centre of the CRPD where students had the opportunity to experience speaking in front of the public and verifying own understanding, reinforcing their knowledge, being aware about own communication skills and probably raising satisfaction and self-esteem.

Acknowledgements

This project was funded by the 10.2.5A FSE-PON Programme. We thank the Centro di Ricerca, Documentazione e Promozione del Padule di Fucecchio for the valuable contribution of its expert staff and all people who agreed to participate in the survey.

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http://www.answerthepublic.com

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"THE STREAM IN A TRAP" EDUCATIONAL PROJECT ON RIO MAGGIORE STREAM IN LIVORNO.

Pellegrino L.[1], Castellano D. [2], Ugolini F. [3], Rossini G. [1]

[1]*Institute of BioEconomy – National Council of Research, Livorno, Italy, graziella.rossini@ibe.cnr.it, laura.pellergino@ibe.cnr.it*
[2]*Scuola Primaria Thouar – Istituto Comprensivo Don Roberto Angeli, Livorno, Italy*
[3]*Institute of BioEconomy – National Council of Research, Sesto Fiorentino, Italy, francesca.ugolini@ibe.cnr.it*

Abstract

In September 2017, Livorno had been hit by a tremendous flood caused by an extremely heavy rain that caused river floods, moving water, sediments and wood biomass from the close hills down to town. Here, canalizations and covered rivers did not sustain such amount of water and flooded, causing damages and deaths. One year later, the primary school Thouar (Circolo Don Angeli, Livorno) agreed to participate in the project "Trapped rivers: a look at the streams from Livorno hills down to town" with the aim to observe and analyze the impact of urbanization on rivers and water management and understand the importance of river ecosystems and natural habitats. The objectives of the project were to engage students in:

- mapping urban streams from the spring to the mouth;
- analysing the ecosystems along the streams and the quality of the water.
- reflecting about the effects of climate change and urban soil sealing and river coverage.

A class of 20 pupils took part in the project. Students were engaged in an oriented inquiry-based learning project, implementing outdoors activities, hands-on activities and experiments, brainstorming and debating.
The preliminary engagement was an exploration along the urban part of the "Rio Maggiore" stream, where students could make observations on the shape of the stream, the land use along the stream by mapping the sealed and non-sealed areas; the water flow, sediments and vegetation. In a second outdoor excursion, they explored the natural part of the stream, near the source on the Livorno hills – a chain of hills at the shoulder of the town. From these observations, they hypothesized the reasons of the huge flood and in the classroom, they debated about observations made more specific experiments and studies. For instance, by calculating the sealed surface from their maps and simulating an heavy rain, they calculated the amount of runoff water. They discussed about the land morphology of the territory, the slope of the hills, the distance from the town and the river characteristics from the hills to the town (e.g. considering the effects of vegetation and river management on the water flow). A conceptual map made by a debate guided by the teacher summarized the collected observations. The paper describes the project application and the educational achievements.

Keywords: flood, inquiry-based learning, primary school education, river investigation.

Introduction

Livorno is a city on the western coast of Tuscany, Italy, hosting the biggest harbor of the region. Only in the XVII century Livorno harbor became one of the most important habours in the entire Mediterranean basin, due to the duty-free port, and laws that established a well-regulated market, freedom of religion and amnesty to people with penance given by clergy in order to conduct civil business. Since the end of the 17th century, the rapid and intense urban expansion has caused land sealing and the alteration of most rivers' flow. On this regard for instance, Rio Maggiore stream was partly covered.
On September 10 in 2017, an extremely heavy rain occurred in the area reaching the maximum intensity at 3 a.m. Electric shortcuts and flooded streets worsened during the day when 200 mm of rain fell in a few hours especially

near the springs of the streams Maggiore and Ardenza where the recorded rainfall was 242 mm. Such rain caused overflooding.
Rio Maggiore, which was partially covered in the '80ies, overflowed at the entrance of the culverted part, flooding into a private house nearby and killing four people. Rio Ardenza overflowed along the two kilometers in the urban area, at Tre Ponti locality (Fig. 1).

Figure 1. Aerial photo of the flood occurred on the 10th of September 2017 (source: https://livornopress.it/wp-content/uploads/2017/09/Stagno-foto-aeree-3.jpg).

The presence of hills in the proximity of the town has hampered the amount of water and sediments flowing down to town. The Provincial Park of the Livorno Mountains, recently transformed into Regional Nature Reserve, is a 1329 hectares wide woody area, representing the green lung of Livorno area. The forest area actually extends for 3300 hectares embracing other municipalities: Collesalvetti and Rosignano. The Park is a unique example of Mediterranean maquis and shrubland with a gradient from the coastline to the inner part. The garrigue characterizes the area closer to the rocky coast, while inner scrublands with dense and impenetrable vegetation is the transient zone to the taller vegetation in the innermost areas. In the forest, the main tree species are heather, holm oak, elm, cork oak, depending on the ecological conditions, and among the herbaceous plants, wild orchids are of important value. Other species such as poplars, black and white hornbeams, willows and ash trees are typical along the streams. The fauna includes typical European species like wild boars, foxes, wolves, martens and porcupines together with migratory and stationary birds.
Besides the natural elements, the Park includes also ancient archaeological findings and important monuments, such as the Sambuca and the Poccianti's Aqueduct, the Biogenetic Reserve of Calafuria with the Roman quarries of sandstone and numerous landscape and historical witnesses.
Since many years, a collaboration between local organizations (Biodiversi NGO, WWF Livorno, NaturAma CTT Nord and the Institute of BioEconomy-CNR) has been promoting the Livorno Hills through volunteering, historical-naturalistic excursions and educational projects for primary and secondary schools.
Currently, the Municipal urban Plan of Livorno city is based on the "zero" net land take principle, which gives priority to regeneration projects following the regional policies for territory governance. In practice, the Municipality of Livorno has committed to re-design 35 areas within the urban fabric, following strategic objectives and functions for new forms of economic development and fostering Urban Resilience in operational planning.

Thanks to the synergy created in the area between research institutions, local associations, environmental guides, the project "Trapped rivers: a look at the streams from Livorno hills down to town" was conceptualized with the

aim to raise young people's awareness on the importance of river ecosystems and natural habitats and threats by human actions.
In order to achieve such aim, it is important to use engaging tools and educational methods that can play a strategic and effective role in education and increasing environmental awareness. The project was implemented by the primary school Thouar of the Circolo Don Angeli in Livorno together with the Institute of BioEconomy and local environmental guides.
From the educational point of view, the project's objectives, for both teachers and students were:

- Implementing Inquiry Based Learning in scientific subjects.
- Learning how to implement scientific experiments with data collection and analysis;
- Learning how to discuss the results and increase critical thinking;

Regarding the topic:

- Mapping rivers' flow and land use along the rivers;
- Analysing river ecosystems and the changes from natural to urban environment;
- Raising awareness about the effects of climate change on water flow and management;
- Raising awareness about the effects of urbanization and human impacts on river ecosystems.

Methodology

The project was implemented within the framework of the school curriculum and its duration was about 20 hours. The inquiry-based learning methodology was applied through outdoors activities to stimulate students in the observation and the investigation of specific aspects of the Maggiore stream.
We followed a five-step cycle model in which phases are identified (Pedaste et al. 2015) as follows:

Orientation is the phase in which the interest and curiosity is stimulated in relation to the problem or the topic. The teacher introduces the topic to the class, raising emotions and stimulating students to tell their personal experiences in connection.

Conceptualization is a process of understanding a concept (or concepts) belonging to the stated problem". Students should formulate hypothesis on a topic, thinking about the relationship between possible influencing variables (Mäeots et al. 2008).

Investigation is the phase in which students and teachers are in action, to answer questions and test hypothesis" (Scanlon et al. 2011). This is the practical phase in which the students perform experiments, field observation and analyse the data. Data interpretation follows data analysis and relative results, in order to find the relationship between variables.

"Conclusion phase gathers the results and the interpretations from the investigations and experimentations made within different school subjects". In this phase, students get an inclusive picture of the findings related to the addressed issue.

"Discussion includes the reflection of the students on the findings and the communication to others about the activities and the results". By telling other peers or adults the story of their project, students reflect and clarify their understanding, and find the way to explain the acquired concepts by using their own words.

Results

In the *Orientation*, students were asked if they had any thoughts coming out from the word "river". Most of them recalled the dramatic moments of the flood occurred one year before. All students had a memory to share about that experience. Students were enthusiastic about the possibility to investigate the streams that became so dangerous in just one night.

Opening Google Maps, pupils could trace the river bed on map and observed the different landscapes and land morphologies crossed by the stream, brainstorming on slopes and distance between the hills and the sea but also noticing the “hidden” part of the stream as it has been covered.

In the *conceptualization*, they were asked what was their opinion about why the flood occurred. They hypothesized that the flood occurred because of different reasons:

- the amount of rain;
- the river slope;
- the covered part of the river.

For the *investigation*, students were brought to visit the urban part of the Maggiore stream to test their hypothesis. An observation of the land use along the stream was reported on map, coloring the sealed areas in grey and the green areas in green. This activity also was useful to test students’ orienteering skills, dealing with geographical information (cardinal points, Earth rotation etc.) and to approach the concepts of land cover and land use. Brainstorming focused on the effects of soil sealing and its effects on rainwater runoff, preenting water infiltration in the soil.
Then, the students were organized in four groups and let them free to explore the river ecosystem by theme: river characteristics, vegetation, water, soil. Each group was accompanied by an adult and students were partially guided but left them free to explore and collect pictures and samples. They were equipped with plastic bags, jars, scissors, lens, pencils and notebooks, camera etc. for sampling materials, making observations etc.

Figure 2. Students analyze the soil texture along the stream in the urban context.

Also along the river, brainstorming focused on the management and restoration actions of the river banks: some parts of these were restored by using big rocks, other parts covered by reeds were managed with clearing cuttings; while in other parts excluded from maintenance works were characterized by higher biodiversity in vegetal species.

Figure 3. Students recorded observations and notes and took pictures using digital devices.

During the second outdoor experience, the students visited the stream in its natural part (Fig. 4), in the Livorno hills, guided by an environmental guide. In such context, they were able to observe the woodland and to acquire knowledge on some of the most important species of natural water courses such as alder, willows and other species of the Mediterranean maquis, besides other organisms typical of watercourses (amphibians, macroinvertebrates, etc.). They took samples of forest soil to compare color, structure and texture to the ones of the urban soil.

Figure 4. Students in the second excursion in the natural part of the river.

More experiments were performed in the classroom, for instance they investigated the particle distribution of the soil samples; identified the vegetal species collected or photographed during the field trips.
Students gathered all the observations and finally, they made a debating session in which they summarized the results and made an analytical discussion of the observations and experiments carried out in order to build up a conceptual map (Fig. 5).

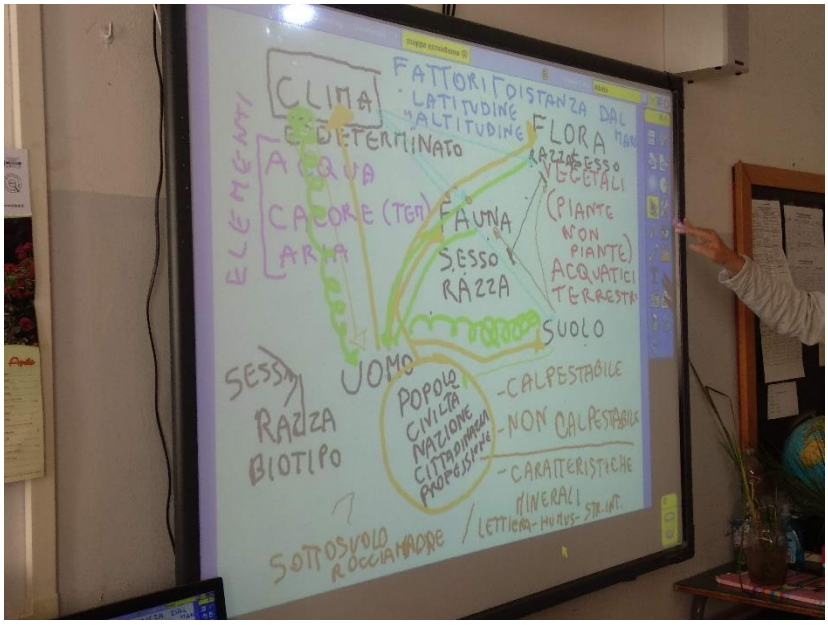

Figure 5. Conceptual map obtained from the debate in the classroom.

Discussion and conclusions

The teacher contributed substantially to the activities which led to the creation of a conceptual map on the river, its functions, benefits and threats. From the pedagogical point of view, guiding some conversation, the teacher invited pupils to listen, comprehend and produce narrative, descriptive and iconic texts. In this way, students were stimulated in verbalizing as written or oral form the acquired information.

In addition, the creation of simple tables, maps and conceptual maps were useful to compare the two environments (urban vs. natural) and to describe and summarize the problems found.

From the methodological point of view, dividing the class of students in heterogeneous groups of 5-6 students with tasks assigned on specific topics, allowed to collect accurate information in a relative short time. Observations and data obtained from experiments, exercises and calculations were summarized in tables and graphs that were shared among the pupils. This allowed them to learn sharing information and tasks and to repect the pace of work. In addition, they learnt also how to search for information from different sources of knowledge that were useful to compare the different parts of the river but also to know the evolution of the stream over the time and to discuss about possible solutions to specific problems.

From the educational point of view, the application of role-play and linguistic games stimulated and trained students in the narrative. The aim of such activities was to stimulate imagination, observation, reflection and critical thinking as well as creative skills. In addition, they facilitate the expression of the personality and win shyness.

It also seems that students raised their awareness on the diversity of environmental and management characteristics of the stream in its urban and natural contexts, but also on the weaknesses of the stream and the areas along it, especially in the proximity of the culverted part. Students were stimulated to raise their sensitiveness towards the environment where they live and to build up a shared memory of the experiences.

The variety of activities covered several subjects such as literature, history, science, math, geography, art/image, informatics, environmental education and education to citizenship. The whole process was dynamic and allowed to face students with physical and real objects and observations, building up a heritage of experience and knowledge that can be used in other contexts, favoring the scaling up of the conceptual information to national and European level.

However, the critical aspect concerns the time needed for implementing the whole learning process, as many investigated aspects deserve further deepening while time available is not enough.

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River management in a changing climate

Co-funded by the Erasmus+ Programme of the European Union

THE CLIMATE CRISIS AND ITS IMPACT ON THE TERRITORY. ECONOMIC AND SOCIAL EFFECTS

Bernardo Gozzini

Institute of BioEconomy – National Council of Research, Livorno, Italy

Abstract

Extreme weather and climatic events (heat waves, heavy rainfall, drought, etc.) have always had and will continue to have significant consequences for society in addition to economic damage. In this paper is analyzed the situation of signs of climate change at global and local level. From the situation of the arctic sea ice extent to the trend in temperature and rainfall data in Tuscany

Key-words: climate change, temperature, precipitation, arctic, green deal

Introduction

Extreme weather and climatic events (heat waves, heavy rainfall, drought, etc.) have always had and will continue to have significant consequences for society in addition to economic damage. They may, for example, interrupt the provision of health and social services and may damage their infrastructure.

A first analysis of the economic impact of climate change on Europe has been presented in the report “Climate change adaptation and disaster risk reduction in Europe. Enhancing coherence of the knowledge base, policies and practices” realized in 2017 by European Environment Agency (EEA). In the report, the economic losses caused, in the period 1980-2015, by climate events in the member countries of the EEA were quantified at € 433 billion. Between the extreme events, the hydrological (in particular floods) and the meteorological (in particular storms) represent each approximately 39% of the recorded damages, followed from the climatological events for a 22% (in particular drought).

From the point of view of social impact, according to data from The International disaster database (EM-DAT; https://www.emdat.be/), the heat waves are those that cause the largest number of human losses in view of their spatial extent and impact on the weakest individuals.

Heat waves have a greater effect in southern and western parts of Europe, while cold waves generate the largest number of deaths in Eastern Europe and finally floods and landslides have the greatest impact in Southern and Eastern Europe.

Even the worldwide data do not differ from the European data, the insurance company SWISS RE has recently (2019) released a report in which it indicates that the worldwide economic losses in 2018 were of 165 billion dollars, of which 155 for hurricanes, floods and fires and only 10 for terrorist acts, while in 2017 the total losses amounted to 350 billion dollars. The biennium 2017-2018 was the most expensive in the absolute sense with losses of the order of 515 billion dollars.

From these data it is clear that the climate is changing faster than expected and its impact is becoming increasingly evident. The scientific community agrees that we will have a significant increase in the intensity of these events while on their frequency, there are still elements to be analyzed in depth.

Global and local situation

The concentration of carbon dioxide reached a peak of 417 ppm in June 2020 and in 2019 there was an increase in the concentration of CO2 of 1.7% compared to 2018.

NOAA data (National Oceanic and Atmospheric Administration https://www.ncdc.noaa.gov/sotc/global/201913) showed that, from 1880 to today, 2019 was the second hottest year behind 2016 alone (Fig. 1). The increase in

temperature observed in 2019 is 0,95°C, while 2020 currently (September) is hotter than 2019 (0,97°) approaching the fateful threshold of + 1° equal to 2/3 of the +1.5° identified by the Paris agreement of 2015, during the Conference Of Parties (COP21), as the world's benchmark not to be exceeded.

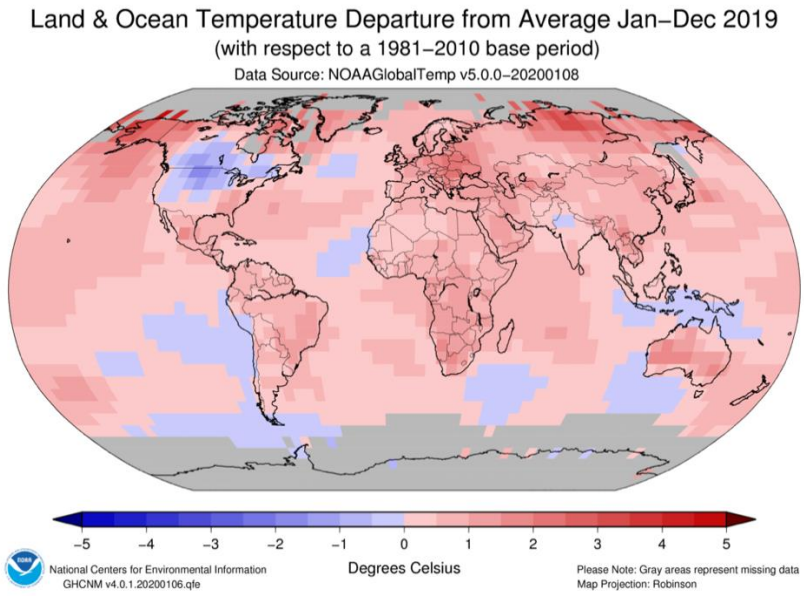

Figure 1. Temperature anomalies during 2019 with respect to a 1981-2010 base period.

This threshold was also confirmed in a recent special report by the Intergovernmental Panel on Climate Change in 2018 (https://www.ipcc.ch/sr15/). A recent prediction released by the UK Met Office now suggest around a 10% chance of at least one year between 2019 and 2023 temporarily exceeding 1.5C." (https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2019/forecast-suggests-earths-warmest-period)

The Arctic region

The ice extent to the North Pole, detected by satellite since 1979, is steadily decreasing. For the North Pole the summer 2020 has been the hottest since the data are systematically observed, and this has led to a strong reduction of the ice pack. Between 13 and 15 of September 2020 the second smallest extension was recorded since 2012 (Fig. 2). With the shrinking of the Arctic pack some polar maritime trade routes are freed, the famous Passages North-East to North of Siberia and North-West to North of Canada. Some scientists argue that the North-West could be open by 2050 for at least 5 weeks a year and the North-East for a few months a year.

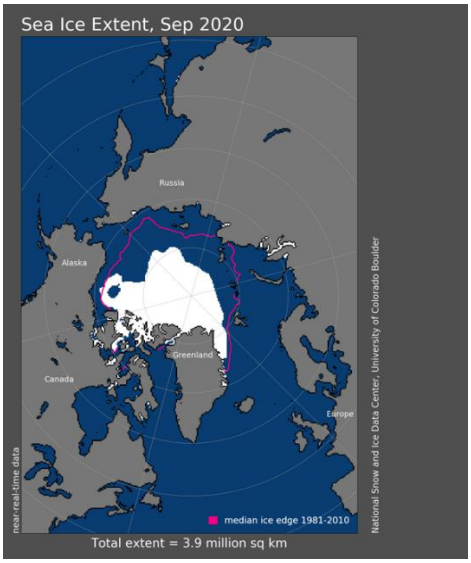

Figure 2. Arctic minimum seasonal sea ice extent which occurred on September 15 2020

Arctic travel is still dangerous because of the harsh climate, lack of nautical charts and the difficulty in search and rescue operations. Despite this, the Venta Maersk was the first cointaners ship to complete the route traveling from East Asia to Northern Europe in 2018, passing North of Siberia, with some difficulty, it had to request the intervention of a Russian icebreaker. The trip lasted 10 days less than the traditional route passing through the Suez Canal with an obvious strong cost savings but the Arctic ecosystem saw for the first time in its history such a sea giant.

Considered almost impenetrable in the past, the Arctic now assumes a new strategic importance due to the melting of ice and the consequent accessibility of resources. Some estimates indicate that the Arctic resources could contain up to 1/8 of the world's oil reserves and 1/3 of the natural gas of the whole planet. The absence of ice will facilitate access to the Barents Sea and the Kara Sea where it is believed that much of Russia's oil (65%) and natural gas (91%) resources are located.

Eight nations surrounding the region are fighting to claim and defend their rights in the area which remains one of the most difficult on the planet in which to exercise power where it would be necessary to find a shared governance for this area of the planet. There is an Arctic Council (https://arctic-council.org/en/), an international forum discussing the problems of Arctic governments and indigenous Arctic populations, which includes eight states: the USA, Russia, Canada, Finland, Norway, Sweden, Denmark and Iceland. These are joined by some «permanent observer members» including Italy. Italy has been present, as a «permanent observer member», since 2013 with the Italian Airship Arctic Base and the Amundsen-Nobile Climate Change Tower. The Arctic permafrost, a soil typical of the extreme North Europe, Siberia and North America where the soil is perpetually frozen, is melting faster than expected causing the ground to collapse, forming craters and lakes and releasing greenhouse gases (methane) that could accelerate climate change. In Greenland, for example, in Kangerlussuaq, the airport has been closed because the runway, because of the thawing of permafrost, is continually being repaired, a major problem for a country where there are no roads and the only means of transport are aircraft or ships.

The Mediterranean and Europe

The Mediterranean region is considered worldwide as a crucial hotspot for the global climate issue. Several studies have shown the vulnerability of this ecosystem showing that this area is warming 20% faster than average, causing the appearance of hundreds of alien animal species, the occurrence of megafires and the collapse of numerous fish species. The phenomenon of drought will become more and more persistent exacerbating the problem of water scarcity especially in the countries bordering the Western Central Mediterranean.

At European level Copernicus data (https://climate.copernicus.eu/copernicus-2019-was-second-warmest-year-and-last-five-years-were-warmest-record) confirm that:

- 2019 is the second hottest year after 2016 for very little (0.04° C)
- the last 5 years are in the top 5 places in the ranking of the hottest years
- 2010-2019 is the hottest decade ever recorded
- the average temperature of the last 5 years was between 1,1° and 1,2° = C higher than the pre-industrial level defined by the IPCC.

Italy and Tuscany

In Italy, the hottest year was 2018 with +1.5° C compared to the 1971-2000 climate, while 2019 is the 4th in this unusual ranking (.

Even in Tuscany the data confirm an almost linear increase in temperature with a rate of about +1.1° C every 50 years (Fig. 3), showing the largest increase in summer with +2.1°C/50 years compared to other seasons. The increase is greater in the minimum temperatures than the maximum with an increase in so-called tropical nights (temperatures over 20º C) (Bartolini et al., 2008).

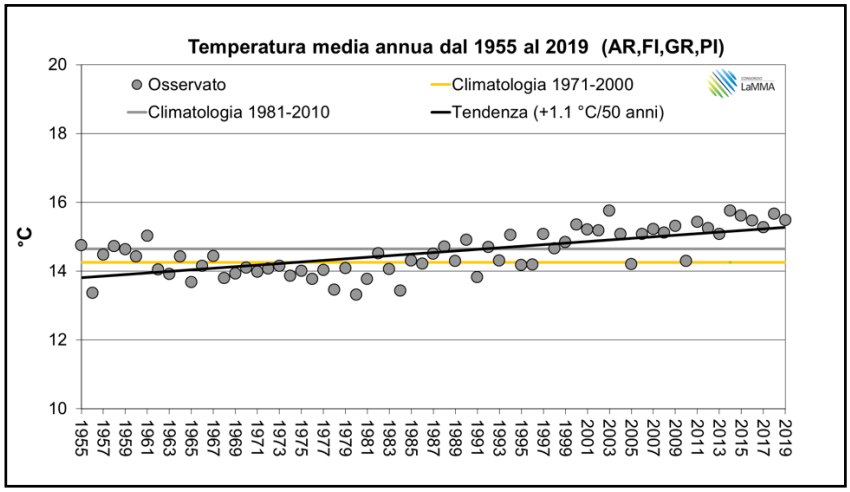

Figure 3. Tuscany annual mean temperature from 1955 to 2019

To better understand the impact of the new climate on generations, we can compare the thermal regime in which lived a girl born in 1996 who today is 24 years old compared to the one lived by a boy born in 1960 who has reached the age of 24 in 1984. The girl has lived with an average temperature of about 1.2° C higher than that experienced by the boy and probably the girl will resist better to the heat but will suffer more the cold having experienced milder winters.

While temperatures data highlight the rapid change in the climate, on precipitation the signal is less evident, more underhanded, more difficult to detect given their stochastic character. In fact, there are no significant signs of an increase or decrease in the precipitation that falls each year on Tuscany (situation similar in most of Italy) and the same is found in the seasonal distribution. The new element would seem the existence of an increasing interannual variability with particularly rainy year followed by very dry ones. This signal concerns the last 10 years and therefore still not significant, to be evaluated in the coming years.

The data show an increase in the rain that falls on average in 1 day. Total yearly precipitation divided by rainy days (those in which at least 1 mm have fallen) shows an increase in daily precipitation statistically significant especially in coastal cities. Moreover, considering the 95 percentile of the number of rainy days, there are significant increases in some cities in Tuscany like Massa-Carrara (Fig. 4), Lucca, Livorno and Arezzo; showing a change in the distribution of rainfalls with the increase of more intense events, more rain in a few hours (Bartolini et al., 2018, Bartolini et al., 2014)).

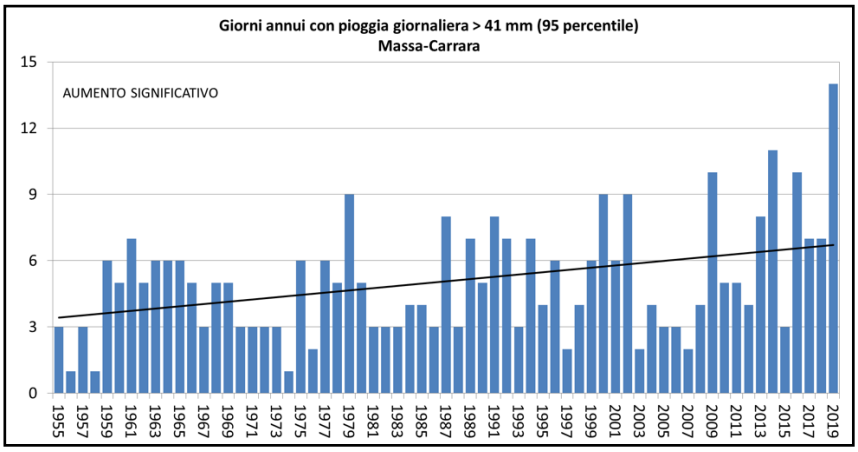

Figure 4. Annual number of 95 percentile rainy days on Massa-Carrara (Tuscany).

This trend is also reflected in some particularly intense and dramatic events. For example, just remember the event of 9-10 of September 2017 in Livorno which caused 9 fatalities and extensive damages. In this case it rained 250 mm in 4 hours in Valle Benedetta, in the hills behind Livorno, 175 mm in Pisa in 6 hours, 165 mm in Livorno in 6 hours, practically what normally rains in the whole spring (March-April-May). This type of precipitation, in addition to causing damage, is not useful because almost all the water falls into the sea.

From a climatological analysis, the month of September 2017, for Livorno and Pisa, will be considered as particularly rainy, therefore an optimal period for the recharge of the groundwater and the presence of abundant water resources. But if you analyse the daily data, 80% of the total amount of monthly rainfall fell in 2 days.

Another important signal is given by the drought that has hit our peninsula every 5 years since 2000 with persistence and increasing intensity (Magno et al., 2018). In Tuscany there is a significant trend in the increase of dry days, less than 1 and 5 mm rainfall (Fig. 5). Particularly persistent was the drought of 2017 with significant damage especially to agriculture and which has led to favourable conditions for the development of a large number of fires that affected thousands of hectares of forest leaving the land devoid of vegetation with a strong risk of erosion with thunderstorms and early autumn rains. 2017 has been a particular year, drought, fires and extreme events like that one of Livorno, a scenario that could be repeated in future also with greater frequency.

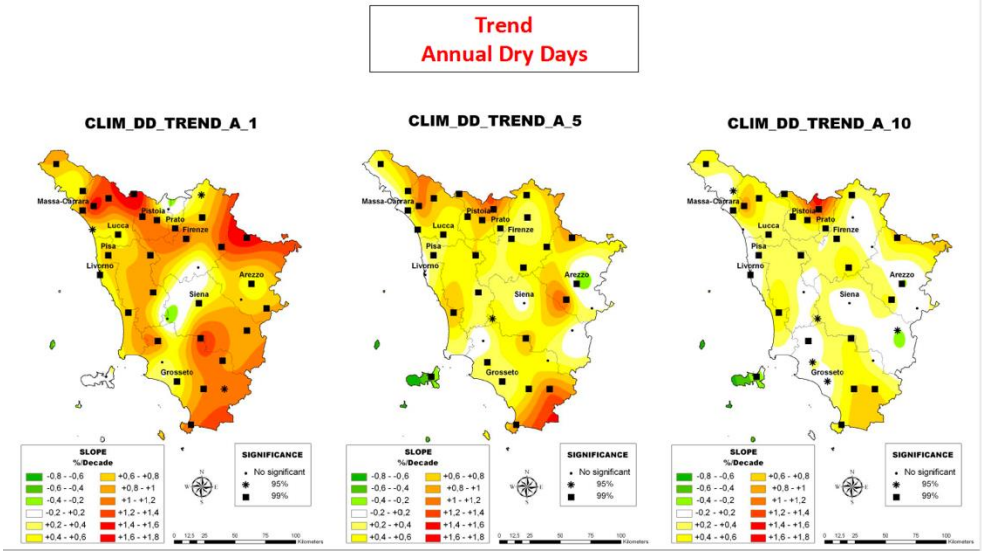

Figure 5. Trend in Tuscany annual dry days with different threshold 1, 5 and 10 mm.

The political response

One of the world's most ambitious programmes to combat climate change is the new «European Green Deal» plan of the new European Commission recently presented by President Ursula Von der Leyen.

After the EU's 2030 targets, the targets are now much more ambitious. Achieving environmental neutrality by 2050 means cutting emissions by 50% by 2030 and if possible by 55%. The EU will devote at least 25% of its budget to achieving these objectives, including in addition to carbon neutral by 2050, there is also the maintenance of European leadership in the field of sustainable industry and technologies, the attempt to confirm and thus consolidate the role of world leader of the ecological revolution to the European Union.
The President spoke of "climate and ecological transition: we no longer need to speak of urgency and the obligation to act, no longer, because we must take action and implement our green deal for Europe, the work to do so begins today. The cost of inaction would be much greater». «Our goal is to reconcile the economy with our planet, cut emissions but create employment and strengthen innovation», through a «new EU growth strategy that gives more than it takes away» and that wants to make the EU «leader» in the clean economy. He also said «I am convinced that the old growth model based on fossil fuels and pollution is out of time and the world», convinced that the Green Deal is a project «ambitious, but we must be very careful to assess the impact and every single step we take».
The objective of emission neutrality for 2050 would be a strong signal despite the fact that Europe is responsible for only 10% of harmful emissions worldwide, therefore a small percentage but the underlying project is to make the environmental battle a new model that identifies Europe as a reference point for becoming the first sustainable democracy, World leadership based on the idea of reconciling economic growth and environmental protection.
From 1990 to 2018 in Europe, greenhouse gas emissions were reduced by 23% while GDP increased by 61% so produce more and less pollution can be achieved.
The EU plan may not be enough but at least it is an innovative project, to be implemented quickly to become an example worldwide because, as Master Manzi said, it is never too late.

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WATER SERVICES PROVIDERS AND DAYLIGHTING RIVERS PROGRAM

Sbandati A.

Confservizi Toscana, Florence, Italy, asbandati@confservizitoscana.it

Abstract

Local companies providing water services to customers (drinkable water, sewage, treatment plants) manage usually only the “artificial phase” of water cycle (pipelines, trunks, tanks, plants, meters). Connections with the environment are limited at the water withdrawal from rivers, lakes, see or underground sources, and at the waste water (treated) releases, usually in rivers, lakes, or see. So water service companies “manage water” but are not involved in direct managing rivers, other public bodies usually are responsible for them.

But at the same time providers are responsible of the use of water and of quality of water, thanks to their policies in supply and depuration. Water companies usually know very well the local water resources, they stock a lot of data and information, so they are indeed one of the most important subject of water policies. Customers and public opinion then know very well local water service providers, and expect from them to be a water operator in all the aspects. For this reason communication and information strategies of companies toward customers and citizens must consider the water resources as a whole, the natural cycle, the life of rivers first of all.

With this approach Tuscany water services providers started to be involved in daylighting rivers projects: in all the cities may rivers have been covered or moved, and renaturalization projects have been started. But important is the role of companies in information and education programs, to tell to citizens and students’ stories about the changing of status of rivers and channels. In Florence in 2020 the company Publiacqua started an educational program about the historical aqueducts (from roman one, to Renaissance, to ‘800). An important way to have contact with customers, improve company reputation, enforce local identity.

Keywords: water service providers-companies, river data/information, story of aqueducts, education, reputation.

Water services providers and “water”

In most cases, local companies provide water services to customers (i.e. drinkable water, sewage, treatment plants) and manage the “artificial phase” (Fig. 1) of the water cycle (e.g. pipelines, trunks, tanks, plants, metres). Connections with the environment are limited throughout the water withdraw from rivers, lakes, sea or underground sources, similarly during treated wastewater release back into rivers, lakes, or sea. Therefore, water supply companies ‘manage water’ but are not directly involved in rivers management; other public bodies are responsible for handling the environment.

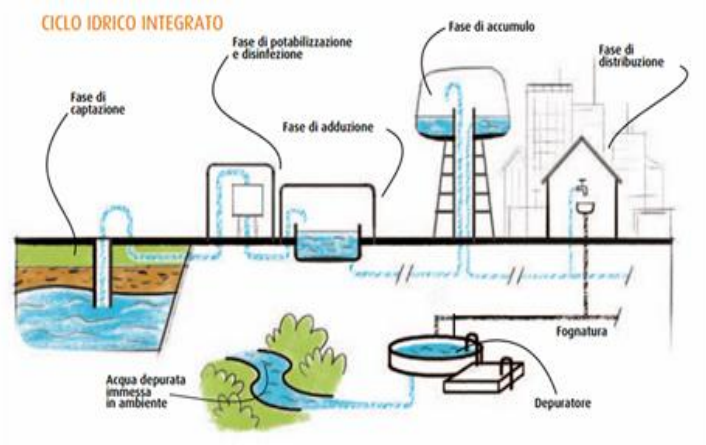

Figure 1. “artificial” integrated water cycle

While at the same time, suppliers are responsible for the water usage in addition to the quality of the water through policies in supply and depuration. Water companies are aware of the local water resources due to large quantity of data and information; therefore, they are indeed one of the most important bodies for maintaining water policies. Customers and the general public are aware of the local water service providers and expect from them to be well rounded water suppliers including maintaining all water related activities (a water company). For example, people consider the service provider responsible of the quality of the river and channels crossing the cities, appreciating the possibility to use again the river for different activities and complaining about pollution.
For this reason, communication and information strategies of companies toward customers and citizens must firstly consider the water resources as a whole in addition to the natural cycle and the life of rivers.

Water service providers as “water companies”

Daylighting waters projects

Tuscany water providers can be involved in programmes concerning daylighting rivers based in cities, covered rivers as well as denaturalisation projects. The following figure (2) illustrates the rivers and creeks covered in an urban area in the past and transformed into underground channels for stormwater drainage. Occasionally, these underground channels were or are involved in illegal wastewater discharge and used as sewages. In these cases, the wastewater company has been obliged to remove illegal discharges. In Italy, water service providers have competence in wastewater sewages, whether in case of “only wastewater” pipelines, or “mixed sewages” (also collecting stormwater), but they are not involved in “only stormwater” drainage system, duty of the municipality offices. Thus, water providers in Italy are not the public body with competence in rivers or stormwater channels (they are municipalities, provinces, regional, state or land reclamation consortia), but are interested in being involved in daylighting rivers programs.

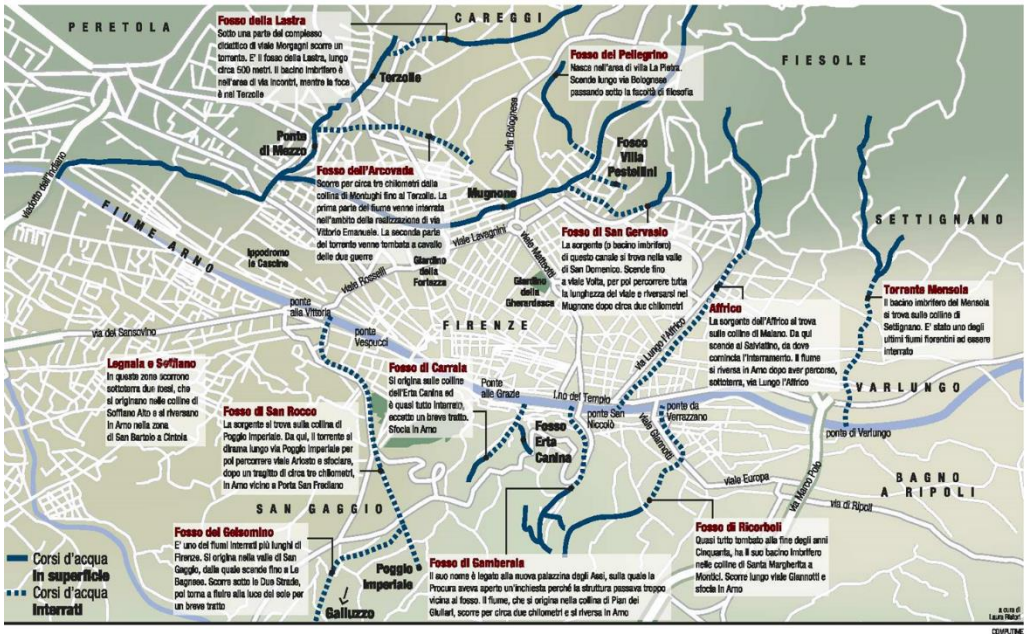

Figure 2. Covered rivers and creeks in the urban area of Florence, Italy.

Water companies and water storytelling: the story of aqueducts

Important is the role of companies in information and education programs, to tell citizens and students stories about the change of status of rivers and channels. In 2020 the company Publiacqua developed in Florence an educational program about the historical aqueducts (from roman one, to Renaissance, to '800's). It was a significant opportunity to engage customers, improve company reputation, enforce local identity.

Thus, it is important for the local water suppliers to tell the customers the history of water in their specific area. A storytelling that usually is highly appreciated by people and tourists.

The story of water in a city is made up of many different tales.

The key story for a water service supplier is the one concerning fresh water systems and waste water organization over the centuries. The story of a city is mostly the story of its water: rivers, lakes, seas, springs, underground resources. Current organization of water services is the final user of a long story of aqueducts and sewages. Theferore, it is important to make the costumers aware of this story.

The case of Florence is a very interesting one, but every city has a story to tell.

The first settlement of Florence (Romans, 50 B.C) got its water from Arno river and underground water (very close to ground level) but soon a real Aqueduct was built to supply thermal stations, fountains and public buildings as in the Roman's tradition. The Roman aqueduct took water from very far places (20 kilometres), to get good quality, fresh and constant flow of water (Fig. 3). It was impossible to do that using the water existing in the city or nearby (rivers, underground).

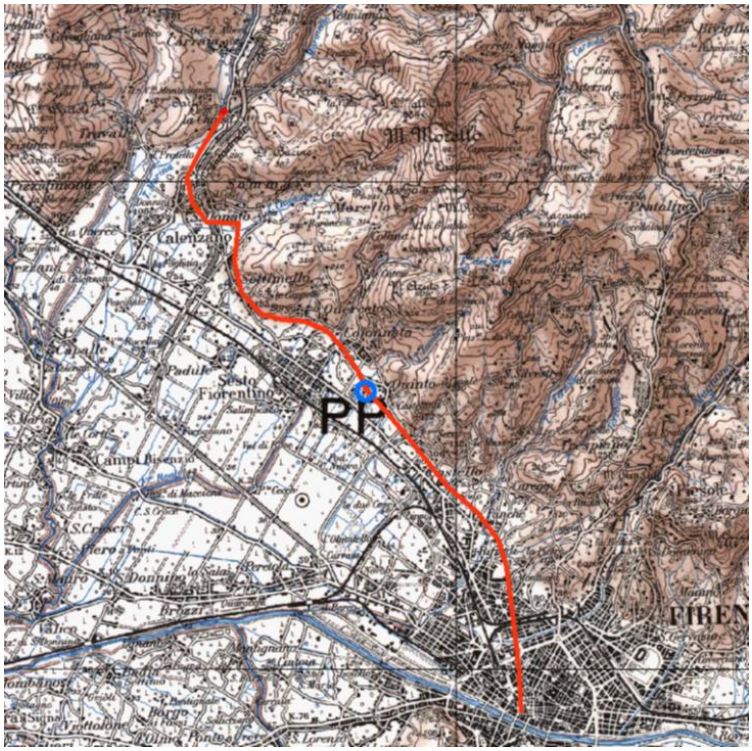

Figure 3. The path of ancient Roman Aqueduct

Unfortunately, nothing is now visible of that public work, the only remainings are paintings (Fig. 4) and some streets name (via delle Terme, via del Capaccio…).

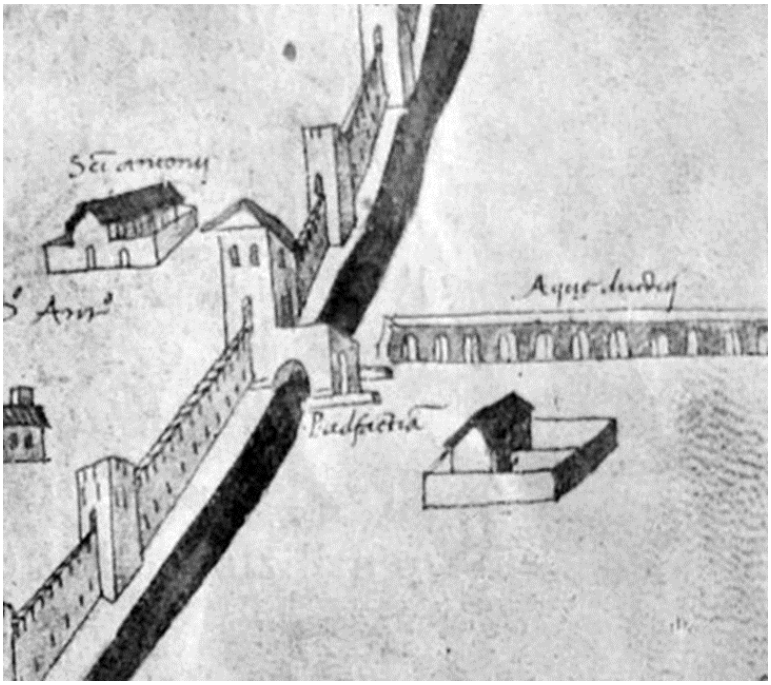
Figure 4. Archedes of Roman Aqueduct in Middle Ages document

In the Middle ages, people in Florence used only underground water for drinking and the water of rivers for washing and waste water.

First aqueducts were built in the Renaissance at the behest of Medici. However, it did not serve the population, but only public fountains and public buildings. In the nineteen century, building of public pipelines construction has begun, using the water of Arno river pumped by the “fabbrica dell’Acqua” (water factory) based in the centre of the city (Fig. 5).

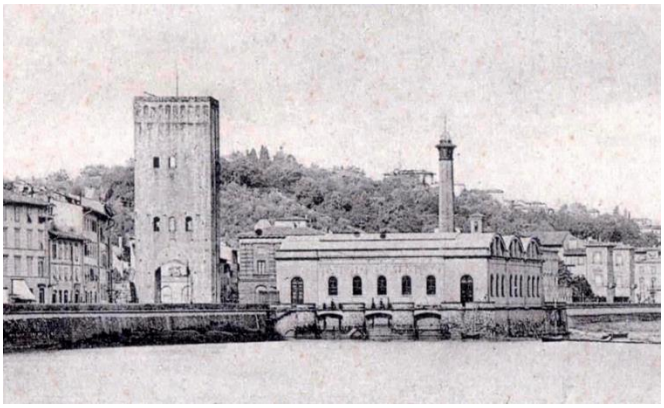

Figure 5. The “factory of water in an early ‘900 photo.

In the twentieth century, the current scheme of aqueduct was completed. Recently the Florence area water service provider, Publiacqua ltd, started to organize guided tour in an historical tank (Carraia Tank), built in ‘800. It’s really a monument, for architectural design and external garden and fountain, and public appreciated so much the visit to a very “unknow” piece of Florence history. Publiacqua and Florence municipality decide to restore the entire area, with an important investment, publishing a book on the history of old Aqueduct and of the Carraia tank (Fig. 6).

Figure 6. Carraia tank, interior view.

The story of rivers and channels

Moreover, water service suppliers can tell customers stories about the rivers, creeks and channel of the city. For instance, in Florence the Arno river path has been modified several times along the centuries, due to the extension of the urban settlement. The rod of the rives has become increasingly constrained, and this is an interesting topic related to the relationship between natural resources and human activities (Fig. 7).

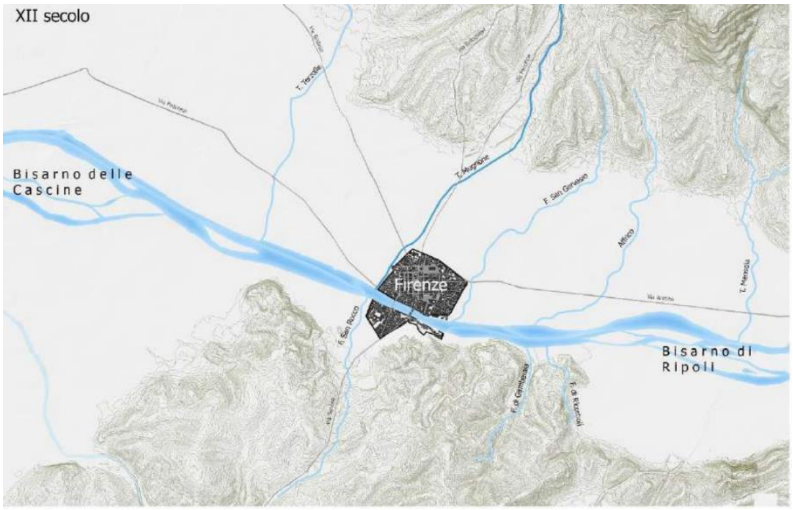

Figure 7. Free movements of Arno River in XII century.

The most important tributary of Arno in the city area, the river Mugnone (Fig. 8) has been moved several times from its own path, according to the necessity of changing walls perimeters.

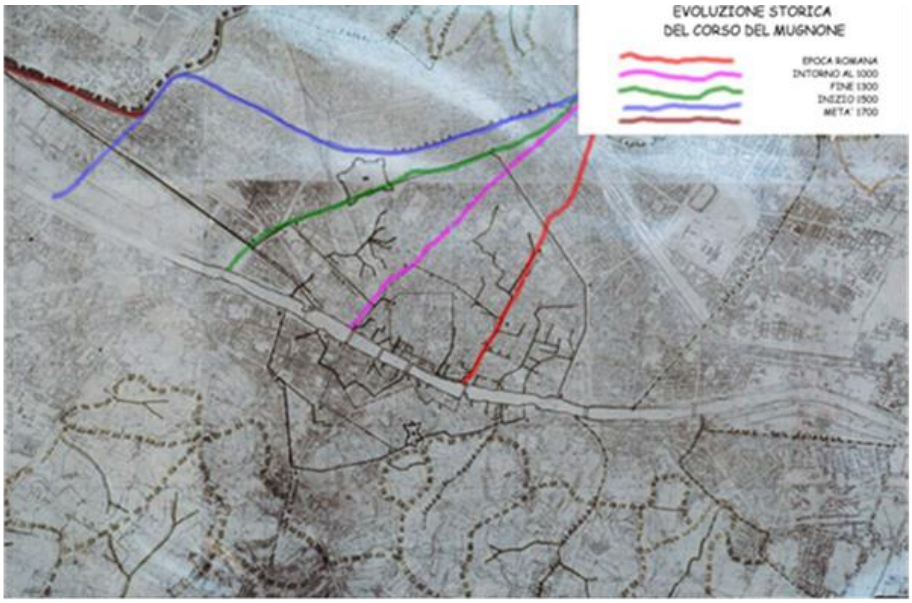

Figure 8. Changes of the Mugnone river over the history, from the roman times (red line) until mid '700 (brown line).

At last, an artificial channel was built in the Middle Ages, the Fosso Macinante, to bring water to mills around the city (Fig. 9).

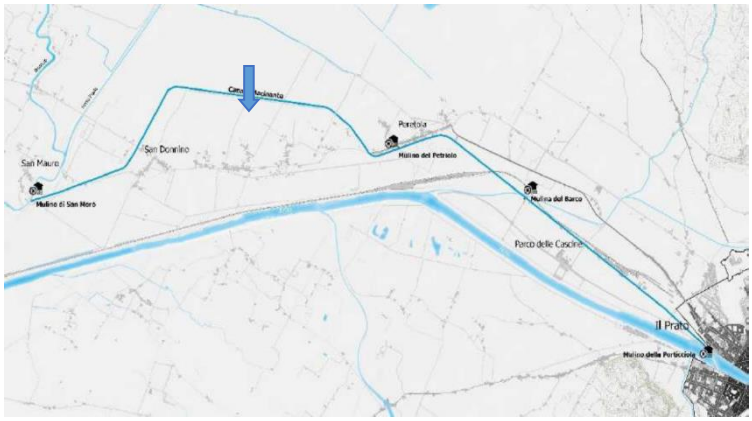

Figure 9. Macinante canal (thinner blue line) built to bring water from the Arno rivers to the mills located around the city.

The above are three short examples proving how interesting and exciting could be to share with customers the story of rivers or channel in a city.

Conclusions

In conclusion, it is important for customers to recognise water suppliers are not just companies with large network of pipelines but mainly as quality and sustainable water suppliers. Reputation increases if the company communication includes a storytelling of rivers, channel, fountains, aqueducts, because the story of water in a city straighten the local identity. For these reasons, daylighting rivers project are a chance for water providers to develop communication and information campaigns dedicated to citizens, tourists and schools.

Co-funded by the Erasmus+ Programme of the European Union

CIVIL SOCIETY, ECONOMIC INTEREST GROUPS, SCIENCE, POLITICS AND POLICIES ON A WATER-RELATED ECOLOGICAL CRISIS. MAY INQUIRY BASED LEARNING CHANGE THE GAME OUTPUT IN THE LONG-TERM?

Barberá, G. G.

Department of Soil and Water Conservation, CSIC-CEBAS, Campus Universitario, Espinardo, Murcia, Spain, gbarbera@cebas.csic.es

Abstract

In this communication the eutrophication crisis (2015 onwards) of the Mar Menor lagoon (SE Iberian peninsula) is reviewed in a wide context. The lagoon is located in a semiarid Mediterranean region where water is one of the most important cultural, social, economic and political issues. The processes leading to the eutrophication crisis are briefly reviewed. Next, it is described the complicated ecological, social and political ups and downs during the crisis until now with emphasis on the attributed role to the science and scientists and the civil society feelings, protests and proposals. On the ground of this scenario it is discussed in which extension the whole picture is conditioned by the general deficient learning of science at primary and secondary schools and the low scientific culture of the society. Taking this into account it is explored the role of enhancing Inquiry Based Learning as a tool for improved management of complex socieconomical problems with an environmental component.

Keywords: eutrophication, water and society, science and society, environmental crisis, inquiry based learning.

Introduction

Water is both a key economic and environmental factor. This is specially important in dry regions (where precipitation is well under potential evapotranspiration) and, moreover, if the region has a moderately warm climate permitting varied fruit and vegetables production, like the semiarid and subhumid areas of the Mediterranean basin. In this situation, economic and environmental conflicts are unavoidable. The climate change is expected to raise aridity in the already dry regions of the world as soon as mid-21st century (Lickley & Solomon, 2018) and, therefore, unrest about water issues will increase. Better social management of coming crises is desirable. Dealing with this problems need a wider social consensus.

In this paper it is reviewed the case of the eutrophication of the Mar Menor lagoon located in the southeastern of the Iberian peninsula. Although the origin of the crisis is multiple, water, in all the extension of related natural and socioeconomic processes, is the most important factor. In the Region of Murcia, where the lagoon is located, water is of upmost importance in culture, politics and economy and conflicts associated to water problems have been notorious, especially in the last decades.

The Mar Menor eutrophication crisis translated into a regional and national source of (bad) news and political debate. Contrary to former environmental crisis in the region, scientists have been given government and mediatic prominence and citizens have taken multiple initiatives and paid attention to scientific debates. It supposedly should have produced a higher societal consensus about actions to be taken, but this is not the result. On conflict situations, it is normal stakeholders want to lean actions toward their interests. The introduction of formal science advisory boards and the participation of active citizens is intended to balance this situation, but we usually see this ideal is far to be accomplished. What is the role of scientific culture of the population in this failure?

This paper is structured in four sections. The first section describes the historical conditions of the lagoon and its terrestrial catchment as well as the evolution in the last decades leading to eutrophication crisis. The second section is devoted to the interest groups and its positions as well as the role of regional and national government and civil society. In the third section a brief insight into the scientific advisory board role and functioning is reviewed. The fourth section discusses the role of the scientific culture of the population in influencing the current state of the affairs and how a better science education like that based on the inquiry based learning (IBL) approach may contribute to solve these societal problems.

The Mar Menor lagoon and the eutrophication crisis

The content of this section is mainly based on Álvarez Rogel et al. (2020) and Álvarez-Salgado et al. (in press), both coauthored by G.G. Barberá.

Natural state: an oligotrophic lagoon

The Mar Menor (135 km^2; mean depth 4 m) is a lagoon located in the SE of the Iberian Peninsula. The terrestrial catchment of the lagoon (1316 km^2) is semiarid; potential evapotranspiration is 1000 mm larger than precipitation. As a consequence there were no permanent water courses in the area and the agricultural system was dominated by drylands until 1950s. Soils were not nutrient-rich, and inorganic fertilization is, historically, recent. The inner coastline receives the discharge of the Quaternary aquifer, but, due to the scarcity of the precipitation, this discharge, although unknown, was low. With these natural conditions the lagoon was oligotrophic and water column crystalline with excellent vision of the lagoon's bottom, even in the deepest point (7m).

Socioeconomic changes in the last 70 years triggered lagoon eutrophication

Evironmental deterioration of the Mar Menor is due to multiple causes. The development of the tourism occupied >70% of the coastline; unbuilt sections exist because their area is mainly owned by the army. Originally, the inner coastline was occupied by wetlands which buffered impacts of the catchment over the lagoon. For decades sewage was poorly treated and poured in the lagoon, although, at the present, the problem is amended. The demand for recreational navigation induced the widening and deepening one of the inlets communicating the lagoon with the open sea. Salinity dropped and lagoon ecosystem was invaded by new animal species and benthonic vegetation changed. All of this processes are important but the most relevant issue since 1980s is the drastic change in agriculture linked to the availability of new water resources.

The Quatenary aquifer was historically exploited elevating the water with windmills. Around the mills little irrigated orchards were established. In the 1950s new technology and stable energy supplies were introduced and exploitation of the Quaternary aquifer and three other underlying confined aquifers extended all over the catchment increasing irrigated agriculture. In 1979 Tagus to Segura water transfer began and since then irrigated land has multiplied by ten, occupying now over 40% of the catchment. Water resources are obtained from the cited transfer, groundwater, exhaustive use of treated wastewater, and desalinated sea water. Groundwater salinity is too high to water being directly applied to crops and needs to be desalinated. A number of 500-1000 farm-sized desalination plants were installed since the 1990s.

There are three main agrarian systems in the catchment: (i) greenhouses; (ii) citrus trees; (iii) vegetables. All of them are intensive, especially greenhouses and vegetables. The latter usually produce two crops per year, one in winter and another one in late spring or summer. Intensity of production mode is sustained by massive use of fertilizers. The nitrate, because its high solubility, massively percolated to the aquifers, especially to the Quaternary one where is usual to find concentrations 150 to > 200 ppm. Continuous irrigation produced rising levels of the aquifer and lateral discharge to the drainage network and enhanced discharge directly into the lagoon. Moreover, groundwater desalination plants produced brines which nitrate concentration may be > 600 ppm. The brines were poured in the lagoon through a network of > 70 km of purposely built pipes.

As a consequence the Mar Menor passed from receiving very low nutrient inputs from its catchment to very high ones. The effect of enhanced nutrient discharge was apparently buffered by benthic vegetation but in 2015 a phytoplankton bloom reduced light availability producing 85% loss of benthic vegetation loss. Losing this source of nutrient uptake the phytoplankton dominance was exarcebated. In September 2019 a heavy rain (250-350 mm) discharged > 60 $hm^{3,}$ and additional unfavorable weather conditions in the next weeks produced anoxia under 3 m and massive mortality of sessile organisms. Weather changes brought anoxic water mass to the surface killing large numbers of fishes on the beaches and producing a deep impact on local, national and even international public opinion.

Water at the center of the problem. Relation to the Mar Menor crisis.

In a region where potential evapotranspiration is four times precipitation water was, historically, the main production factor. Traditional irrigated lands extend along the floodplain of the only 'real' river, the Segura river and, in much less extent, its little tributaries. In the main flood plain in the low course of the river, complex water irrigation agriculture dates back to the first centuries of the Muslim ruling time (IX^{th} century). The second half of the XX^{th} century witnessed a huge expansion of irrigated agriculture out its traditional 'niche'. One of the most notorious areas for expansion was the terrestrial catchment of the Mar Menor. The relevance of this catchment is easily explained by the combination of an extensive flat plain, good quality soils and an excellent climate for vegetable and fruit crops, especially to supply European markets in winter.

Largest producers and exporters of fruit and vegetables have a special relevance on the regional political, social and economic structure of the region. They are supported by little and medium farmers and the associations of water users, than in Spain are semipublic bodies. The water association of the Mar Menor catchment is the largest of Spain grouping nearly 10000 users. It is to be remarked that the economic weight of irrigated agriculture expands further away the simple crop production. For example, because the production is oriented to supply fresh products to central and northern Europe markets the region the importance of logistical fleets (trucks) is very large in the region.

It would be necessary to have sociological and historical studies but it is not speculative to say that regional culture is deeply permeated by 'devotion' to water. The huge expansion of irrigated agriculture in the last 70 years has not only be supported by the sector profiting of it but also by a majority of the population. The expansion of irrigated agriculture produced environmental degradation that can be summarized in: (i) overexploitation of water resources; (ii) soil degradation; (iii) increase of runoff and flood damage; (iv) pollution by fertilizers and pesticides. While the causes of overexploitation and pollution of water resources is obvious the soil degradation and the increase of runoff is a consequence of the new modes of agricultural practices where the soil is a mere physical support and traditional soil conservation measures is neglected.

The eutrophication crisis of the Mar Menor can be directly tracked to these degradation processes induced by irrigation expansion (although not excluding concomitant effects of other factors not directly related to intensive agriculture expansion). The four cited degradation processes are involved. The explosion of the crisis opened a conflict of interests and emotions in the general population. On the side of interests, the Mar Menor is an important touristic spot for national and foreign tourism but also regionally. A lot of region's citizens have got or rent a second residence of the area. The local properties and business lost value and appeal due to turbidity of lagoon waters, combined with floods on the coastal residential areas in 2016 and 2019, that are directly induced by the lack of soil conservation measures in the irrigated crops. On the side of emotions, the Mar Menor lagoon resulted to be a much more iconic symbol of the region that no one could, probably, to foresee. The scenery of the lagoon have a very high landscape quality, the lagoon is an unique feature of the Spain's coast, and memories (holidays, childhood, relations, etc) of hundred of thousands of citizens are linked to the area. The degradation of the lagoon, with no doubt, impacted this emotional side of the population with an intensity well over any other environmental event occurring in the past.

For first time, an important share of the population openly criticized water-related interest prioritization, and openly asked a reduction of irrigated land extension in the catchment. It has to be noted, that in the catchment and in the region in general the expansion of irrigated lands was supported by the planned expansion (under the umbrella of norms and new resources) always associated to unplanned irregular expansion, that later was regularized. In the Mar Menor some substantiated studies estimate about 25% of the irrigated land being irregular at the present, a figure which does not account for irregularly irrigated lands already consolidated by diverse processes in the last 40 years. The water-related interests robustly responded to these changes in social opinion addressing intense public campaigns and creating new structures like think-tanks to argue in favor of the agricultural model developed in the last decades.

All of this reflected in the political debate and in the administration management. Maybe the most relevant aspect in this issue is the conflict between national and regional government. Spain has a federal-like structure with a lot of competences administered by regional governments, however Water Authority is dependent on the national government when the main basin encompass more than one region (which is the case in this example). Tensions about actions to be taken and which body should do this or the other one action and their financing increased when the national government changed and resulted supported by a block of parties different to the parties supporting the regional government. Regional government defends an approach more based on infrastructures, which are mostly related to water management, superficial or groundwater, while national government bets now for more nature based approaches and control of irrigated areas on irregular situation.

In summary, the problem, associated conflict and proposed solutions orbit around water management, whichever aspect you can imagine. The context is a water ‘soaked’ culture in a place were water was always the main issue.

The role of science and scientists in the crisis

Early after the beginning of the crisis the regional government set up a scientific advisory committee. The composition of the committee was quickly enlarged including people from different institutions, both regional and national and with different backgrounds. The media gave immediate relevance to news, opinions and reports of the committee. Every meeting of the committee got the front page of the newspapers. In this sense, never before in the region science got a so prominent role to confront a major problem.

Soon the committee’s work was dragged by divergence about how the body should work and communicate. The committee was not independent in the sense of being an autonomous body self-ruled. Meeting arrangement and agenda was in charge of government officials, as well as spokeperson was appointed by these officials. At the same time most of the members of the committee were involved, in some way or another, in active research of the crisis. A part of the members of the committee preferred a model where the committee was completely autonomous and responded to concrete questions of the government and some of the members were not satisfied how scientific information was transmitted to the population. The situation did not progress towards a consensus and there was a chain of renounces.

The result of these disagreements within the committee resulted on more attention being paid by the media and the citizens to disputes themselves than to the core of the science behind these disagreements. The important part here is to understand failures in the role of science and scientists in order to improve the management ans social consensus in future crisis.

The feeling is that in the crisis the new relevance given to science fell short of meeting the expectation of contribution everyone imagined. The naive idea under science advisory boards is not to solve social or environmental conflicts but to help to lead them within a reasonable scenario of discrepancy, in the Mar Menor crisis this is not satisfactorily accomplished.

Citizens and science. Do a better scientific culture would improve social consensus?

Social and environmental conflicts are unavoidable. Disagreement in pure scientific terms are part of the science every day life. However, in this example and other examples every one knows as, notoriously the present covid19 crisis, we see that it results really complicated to adjust the advisory role of science in these social and environmental conflicts. When talking about water and the future looming in the climate change it is going to be very necessary to try to improve the role of scientific advisory boards. In this respect it seems the scientific culture of the population is one of the keys. Based on personal observations on the case study environmental crisis I focus in some key questions to be addressed.

Understanding uncertainty

Citizens usually expect from science 'digital' answers, or 0 or 1, yes or no. Politicians and political discussion tend to exacerbate this expectation. Accepting you are not sure of the outcome of your management or policies is like recognizing weakness to your opponent. Every scientist has probably experienced uneasiness to the reaction of the people when the answer to one question is "it could be" or " I don't really know". This situation was recurrent on the Mar Menor crisis. Citizens were disappointed when clear-cutting answers were obtained. Every citizen in Spain receives compulsory education until 16 years old, including science background, however science is mainly taught as "things-we-know-are-true". There is no emphasis or practical approach to scientific method, the true base of science endeavour.

Everyone practicing science deals with uncertainty. Note that understanding uncertainty is not (only) a cool epistemological question. Approach to social and environmental conflict solving is very different if neutral citizens (with no personal or direct interests at stake in the conflict) thinks in terms of uncertainty or simply true/false.

It is clear that no more science content will increase the understanding of uncertainty, it will be necessary much more inquiry based learning, where the students have to confront the nature of uncertainty in research.

No, science is not a pulpit

Not all the lack of understanding of uncertainty is due to poor scientific culture of the average citizen but also to weakness on the scientists' approach to communication. It is not uncommon at all that scientists communicate their findings and educated guesses from a position of superiority, intentional or unconscious. Moreover, when processes are complex, like usually are in nature, and with social derivatives, competence between disciplines easily arise. Each one stresses the importance of his/her own area of knowledge and downplays others.

The outcome of this situation is a pendulum-like oscillation. In the Mar Menor crisis scientific advisory committee enjoyed uncritical respect at the beginning. But as crisis went on communication did not stress enough the nature of uncertainty and there was unbalance on the importance given to each discipline. As time passed this created distrust in the general population as the dynamics of the lagoon was difficult to be predicted. In this aspect we should not to forget that many scientific advisory boards could be used as 'shields' by officials and politicians.

An inquiry based learning let the students face discussion about experiments and facts to be discussed, a better scientific culture so learned would do the citizens more capable to separate the wheat from the chaff.

Judge yourself

In the Mar Menor crisis a web site was created to publicly display the evolution of environmental variables updated. The web site displayed time graphs of these variables. Being this a good initiative is a tool out of the reach of many citizens. The interpretation of data, the ability to interpret graphs, etc, is downplayed in teaching in respect of contents. Inquiry based learning stresses these kind of analyses and a generalization of the approach would let citizens much more prepared to get their own opinion from data if they are adequately informed.

In the absence of these basic skills one could see in the media many wrong or biased interpretation based on data. These biased interpretations were not random but usually associated to some interest groups.

Ways of Nature are inscrutable (or at least complex)

The dynamics of complex socioecological processes is difficult to be predicted. This has a direct impact on the expectation one management action can have in solving an environmental problem. Secondary unexpected by-effects are common. In the Mar Menor crisis many not properly substantiated claimings about the effect of one measurement on the recovery from the eutrophication state have been communicated to citizens. It is necessary the citizens not only understand the uncertainty nature of the prediction but also the possible complicated trajectories of the system.

Conclusions

Better problem-solving of socioecological problems would benefit of higher level of scientific culture by the general population. Clearly getting an adequate level of scientific culture is not going to solve the problem by itself, end with conflicts between groups of interest or reduce partisanship of the political debate but it would do the citizen more autonomous and able to support one or another solution based on a more informed judgement. However it has been discussed that the problem of scientific culture is not about 'encyclopedic' scientific knowledge but about method an epistemological problems. The better approach to increase scientific culture in this respect are not lessons about philosophy of science but the practical approach to the creation of scientific knowledge through inquiry based learning.

Disclaimer

The author of the paper has had a role on most of the events dealt with in the text. The paper may be more biased than usual. It should be critically judged having this in mind.

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RIVER RESTORATION ACTIVITIES IN NORTHERN ITALY IN THE CONTEXT OF CLIMATE CHANGE

Chiarabaglio P.M.[1], Vietto L.[1] Cristaldi L.[2]

[1]*CREA – Research Centre of Forestry and Wood, Casale Monferrato AL, Italy*
piermario.chiarabaglio@crea.gov.it
[2]*Ente di Gestione delle Aree protette del Po vercellese alessandrino, Casale Monferrato AL, Italy*

Abstract

Floodplains in their natural condition are an important part of river ecosystems. Ecosystems services include habitats and biodiversity conservation, flood protection, water purification, recreational value, carbon sequestration.

Recent studies have shown that over the past two centuries 70-90% of European floodplains have been environmentally degraded as a result of, urbanisation, agricultural land use, river straightening and structural flood protection. As consequence of climate changes, increase of human activities and globalisation, across Europe in the next decades it is expected that risks of flood and drought will increase with heavy impacts on riparian ecosystems, water table level and natural tree composition. For these reasons the European black poplar (*Populus nigra* L.), one of most representative tree species of the old natural floodplain forests is considered on the verge of extinction in several European Countries so that many initiatives have been undertaken to protect its germplasm and to implement conservation strategies (EUFORGEN Programme). Over the last decades the importance of poplar and willow in a field that is different from traditional intensive cultivation has greatly increased as they are typical pioneer species and can grow in poor soil and start the natural evolution of forests. The CREA - Research Centre of Forestry and Wood (Casale Monferrato) has promoted and gained relevant experience on environmental applications of these *Salicaceae*. In co-operation with Natural parks and local State-run organizations it has carried out several pilot trials on the Po river basin testing plant materials, planting methods and cultivation techniques. Up to now over than 150 hectares have been restored in different sites. The results obtained may be extended to similar situations by riparian ecosystem managers.

Keywords: river restoration, *Salicaceae*, *Populus nigra*, ecosystem services, climate changes, carbon storage, flood events, alien species, tree species for river ecology.

Introduction

In order to improve biodiversity and to preserve endangered species in the context of climate change, river restoration is one of the strategies adopted at European level (EU Floods Directive 2007/60/EC, EU Biodiversity Strategy 2030). Floodplains are the results of the interactions between hydrology, geomorphology and the biology of the land surrounding rivers (Meitzen, 2018); gravel-bed rivers and floodplains form dynamic ecological networks of complex habitats and corridors of connectivity distributed across the landscape. These meadow land and flooding areas preserve high biodiversity level and provide a number of valuable Ecosystem Services including prevention of soil erosion, water quality improvement, recreational value, wildlife habitat, carbon sequestration and a reduction of storm damages and flooding in neighbouring areas (Van Looy *et al*. 2013). Floodplains have been influenced by humans for thousands of years; near the rivers they established their activities and utilised the areas for food (agriculture or hunting), power (water mills, wood) and shelter, so that floodplains are from ever considered the “cradle” of civilization (Tompkins, 2005). Urbanisation, pollution from urban areas, river constriction, mining activities, alteration of river dynamic, agricultural exploitation are the main striking reasons of floodplains degradation (CIRF, 2006).

For these reasons the European Commission began promoting restoration activities to enhance the quality of rivers through dyke relocation, lowering of riverbanks and recreation of riparian forests. As a consequence several Countries started to restore natural river dynamics (Mansourian *et al*. 2019, Schindler et al. 2016) and to consider revegetation of wetlands an important strategy to implement river restoration (Lilli *et al*. 2020): revegetation can enhance biodiversity (Jiménez-Carmona *et al*. 2020), mitigate atmospheric carbon dioxide (Marks *et al*. 2020), enhance the Ecosystem Services and support climate change adaptations and resilience (Mohan *et al*. 2020).
Reforestation is difficult to plan, expensive and even harder execution: success is subject to weather conditions, weed competition, pest and maintenance frequency. Low survival of pools and seedlings planted in river basin areas depends on soil condition: these are frequently sandy with presence of thick deposit of legacy alluvial sediments (Laub *et al*. 2020); moreover the presence of invasive alien species can significantly reduce efforts to growth the plantations (Langmaier & Lapin 2020) as well as climate change can produce water availability reduction as a consequence of the spatio-temporal distribution of both precipitation and evaporation impact on water supply regime (Konapala *et al*. 2020). In these environmental conditions populations of pest (buprestid *in primis*) can quickly rise to damaging levels.
Poplars and willows as a pioneer species can play an important role in floodplain restoration. These trees can resist to flood events, contribute to raising bar by retaining sand and gravel thanks to their rapid growth (Andreoli *et al*. 2020) and start secondary succession with other trees and shrubs (Tinschert *et al*. 2020). Poplars, and particularly the European black poplar (*Populus nigra* L.), spread and sprout on bare soil and riverbanks along river after flooding (Debeljak et al. 2015; Corenblit *et al*. 2016) and initiate the hydro-morphological processes of island formation and riparian forest development; further a large number of threatened and common species that are associated with or depend on poplars (Rotach 2003).
At the same time, *P. nigra,* a flagship of the old natural floodplain forests in the temperate zone in Europe (Fig. 1), is considered a threatened forest tree species: many initiatives have been undertaken in the last decades to protect its germplasm and to implement conservation strategies within the European Forest Genetic Resources Programme (EUFORGEN) and the European Freshwater Programme (Zöckler, 2000).

Figure 1. Black poplar isolated tree: this specie can be considered on the verge of extinction

To contribute actively to its conservation as well to restore rivers several activities have started at different sites: Morava river (Czech Republic, Pospiskova & Salkova, 2006), the Common Meuse river (Belgium, Vanden Broeck *et al.* 2020), Oder river (Tautenhahn *et al*., 2007), Rhine and Danube river (Germany, Schneider 2010) and the Po river (Italy) (Vietto & Chiarabaglio, 2004). More information are available from the Restoring Europe's Rivers database (RESTORE, https://restorerivers.eu) which reports 1328 river restoration case studies from 31 EU Countries.

Methodology

Since 2000, several pilot trials aimed to convert areas dedicated to conventional crops or poplar hybrid cultivation into floodplain forests have been carried out on the upper part of the Po river basin and its tributaries by the CREA - Research Centre for Forestry and Wood (Casale Monferrato, Italy) together with State–run organizations (http://parcodelpoalessandriavercelli.it/, http://www.ogliosud.it/). To restore floodplain forests and, furthermore, to contribute actively to the conservation of *P. nigra* genetic resources have been the goals of the trials. According to the EUFORGEN strategies (Lefèvre *et al.* 2001), it has been created a network of black poplar small-populations (artificial *in-situ* gene conservation units) that could support a dynamic evolutionary process in a short time. These populations, since have been established on suitable habitat conditions, may serve as founder populations for new establishments over rather large distances, as a source for gene flow into neighbouring natural stands and, lastly, as a seed sources for reproductive material used for restoration activities. Genetic, demographic and ecological factors have been taken into consideration. To assure adaptation to the local environmental conditions we used only stock of genetic materials from local collection or neighbouring provinces, with a high genetic variability (proportion of unrelated genotypes, number of pollen donors, balanced sex-ratio). These materials are maintained in collection and annually propagated at the experimental farm “Mezzi” of CREA. As the pattern of planting is also important, mosaic of clonal plots have been preferred to clonal mixtures in order to give to the slower growing genotypes greater chances of survival; the higher number of trees utilised should limit the inbreeding level and will increase the likelihood of effective regeneration.

Poplars have been planted according to 8 × 8 m scheme, pre-soaked and mixed with the other tree species and shrubs in the middle using a square layout; to ensure water availability during the drought period hydrogel has been added to soil when planting. The climatic conditions of the restored sites can be classified as temperate/sub-humid: the average annual temperature is of 12,4 °C and the rainfall of 672 mm/year (141 mm during June to August, with periods of dry spells that can cause water stress to plants). As consequence of flood frequency all the sites were heavily infested by exotic species such as *Sycios angulatus* L., *Solidago gigantea* Aiton and *Humulus scandens* (Lour.) Merr. The potential vegetation of this site is represented by Oaks and Elm groves and is classified as “Riparian mixed forests of *Quercus robur, Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers” Natura 2000 Habitat code 91F0 (European Commission 2013).

To ensure planting success aftercare including tree shelters and mechanical weed control (shredding twice a year) have been used in the first 2-3 years. *Sycios* infestations should be controlled even in the years to come as this weed can also wind around adult plants, preventing the development of tree-tops and causing “suffocation”. The repeated use of grass trimmers, especially when this operation is carried out by unskilled personnel, can cause damages to the cortical tissues of the root collar which can endanger the development of the plant. Under these circumstances it is advisable to resort to localized chemical weed control, using low impact products and with specific equipment (ultra-low volume herbicide sprayer).

Results and discussion

Over 18000 black poplars have been planted in thirty suitable sites (Fig. 2) from 2000 to 2020 via pole plantings together with seedlings of *P. alba*, willow and other hardwood species, about 150 hectares have been afforested.

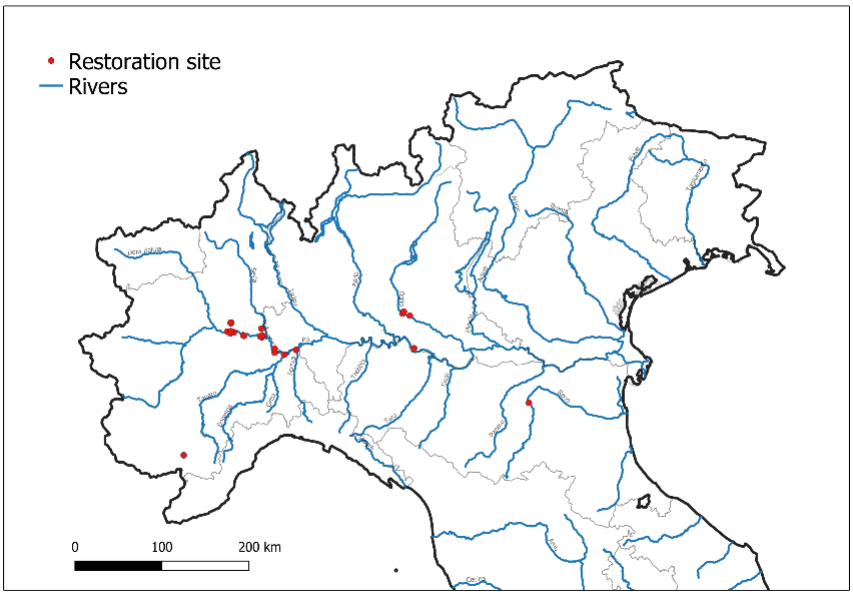

Figure 2. Distribution of restoration sites in the northern plain of Italy carried out by CREA.

To detect poplar survival and growth parameters (height and diameter at breast height) a survey has been carried out in 4 experimental sites in 2019 (total area of about 10 hectares, plants age from 11 to 17 years) (fig. 3). A mortality rate of about 40% (a maximum value of 72% in a site with very low water availability) has been detected among the sites. Observations on 1767 trees showed a total height of 23 meters and an increment of 18 cubic meters per hectare per year ranging from 12 to 22 m^3 ha^{-1} $year^{-1}$.

Figure 3. Black poplar of 8 years old in a restored site in the Po river Park: an example of artificial *in-situ* gene conservation unit.

These case-studies demonstrate that native poplars can be successfully used in restoration activities and that it is possible to convert uncultivated areas into a riparian forest over a short time period, on condition that particular attention is paid to site preparation, pre-soaking of the planting material, after planting care, (weed control, watering in drought, …). As regard the restoration of *P. nigra* attention should be devote also to the genetic origin of the plant material and to the potential introgression with cultivated hybrid poplars: at appropriate sites the reforestation activities with black poplars can result as artificially populations that act as a seed source and might

contribute to the dynamic gene conservation of the species supporting its natural regeneration and adaptation to climate change. By this way, they can contribute positively to the evolutionary potential of the species by improving genetic connectivity of isolated populations in a fragmented landscape via pollen or seed transport.

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PLANNING NATURE-BASED-SOLUTIONS THROUGH GEOGRAPHIC INFORMATION TOOLS TO MANAGE FLOOD RISK ON FLORENCE CITY ENVIRONMENT

Pacetti T. [1], Cioli S. [1], Castelli G.[2], Pampaloni M. [1], Bresci E. [2], Caporali E. [1]

[1] *Department of Civil and Environmental Engineering (DICEA), Università degli Studi di Firenze, Italy, tommaso.pacetti@unifi.it, enrica.caporali@unifi.it*

[2] *Department of Agriculture, Food, Environment and Forestry (DAGRI), Università degli Studi di Firenze, Firenze, Italy, giulio.castelli@unifi.it, elena.bresci@unifi.it*

Abstract

The growth of impervious surfaces due to an exponential and uncontrolled urbanization, the evolution of socio-economic scenarios and the impacts of climate change have made the urban/peri-urban areas weaker against pluvial-flood risk (e.g. issues related to the correct management of the secondary river network, criticalities associated to culverted or covered rivers). Innovative strategies to make urban/peri-urban environment more resilient and sustainable are needed and Nature Based Solutions (NBS, i.e. actions inspired or supported by nature) can play an important role to provide integrated responses to the environmental, social and economic future challenges.

In this context, the aim of the FLORENCE (FLOod risk and water Resources management with Nature based solutions on City Environment) project is to explore the effectiveness of NBS for the flood risk management of the City of Florence (Italy).

The project is based on a quantitative evaluation methodology supported by geographic information tools that clarifies the benefits and co-benefits of NBS, highlighting their limitations and exploring the possible synergies with existing infrastructures.

First, a GIS based analysis has been made in order to map Ecosystem Services (ES) priority areas, analysing the main ES supply and demand. This analysis is coupled with the identification of the constraints (regulatory, urban planning, economic, environmental, social) to realize a multicriteria zoning of Florence urban environment, highlighting the potential areas for NBS implementation. Lastly, the selection of suitable NBS and their hydraulic modelling is carried out in the identified areas. This allows the evaluation of NBS performances and the identification of the scenarios that best respond to the city's green development needs.

Keywords: Flood risk, Nature based solutions, Ecosystem services, Geographic Information System

Introduction

City environment evolution of many Italian cities has been characterized by the progressive increase in impermeable surfaces that considerably alter the water balance, drastically reducing the volumes of water infiltrated into the soil, thus increasing the surface runoff. These problems, combined with increasingly intense and violent rainfall events due to climate change (Zölch et al., 2017), highlight the necessity of going beyond the classic drainage solutions (i.e. sewer systems) that have often shown their inadequacy to face the complexity of present water management in urban environment (Zhou et al., 2014).

Nature Based Solutions (NBS), i.e. solutions that take inspiration from nature itself for their functioning, are an interesting option when dealing with urban challenges because they provide multiple benefits, integrating water management targets with other environmental, social and economic aspects (EEA, 2015).

Many cities have already adopted this kind of solutions and many others are currently introducing them in planning. This effort towards the introduction of NBS must be supported by tools that help defining strategies for planning and setting the right criteria for NBS implementation.
Recent literature has shown the importance of supporting the uptake of NBS with spatial analysis that can help decision makers identifying suitable areas for installation as well as the necessity of defining the right criteria for NBS design phase (Meerow et al., 2017; Li et al., 2020; Kaykhrosravi et al., 2019).
This work aims at identifying the most suitable areas for the installation of NBS within the Municipality of Florence with the primary target of pluvial flood risk mitigation. The analysis is based on a selection of indicators that are combined through a Spatial Multi-Criteria Evaluation (SMCE) to derive NBS suitability maps that can support local institutions to steer future planning towards NBS implementation.

Methodology

Location of the case of study

The municipality of Florence extends for 102.39 km^2 in the north-east of Tuscany and has a population of 378,839 inhabitants according to the ISTAT census of 2019. The topography of the area is mainly characterized by flat areas where residential, industrial, and commercial areas are located while the remaining hully portion of the territory is mainly dedicated to agricultural areas, olive groves, forests and vineyards. The city is prone to hydraulic problems due to the progressive urbanization and the limits of existing sewer system, especially during short and intense rainfall events, causing pluvial flooding in various part of the city.

Methodology and data used

To identify areas most prone to flooding during pluvial floods that can benefit from NBS installation, a GIS-based multi-criteria analysis is used. Five indicators are used: slope, imperviousness, hydrologic soil group, drainage density of the sewer system and social vulnerability index to flooding. The selected indicators describe the environmental aspects of the area and its socio-economics characteristics that are fundamental in determining the vulnerability and the associated overall risk in the city environment (Martin-Mikle et al., 2015; Li et al., 2020; Kaykhosravi et al., 2019; Meerow et al., 2017). The data used comes from Italian open databases and this allows easy replicability of the work. Data and related sources are shown in Table 1.

Table 1. Data inventory.

GIS layer	Format/resolution	Source
DTM	Raster / 10 m	Tuscany Region - Morphology
Pedology	Vector	Tuscany Region - Pedology
Land Use	Vector	Copernicus Land Monitoring Service – Urban Atlas 2012
Imperviousness	Raster / 20 m	Copernicus Land Monitoring Service – Imperviousness Density 2015
Sewer System	Vector	Publiacqua Spa
Streets network	Vector	Open Data Municipality of Florence

The slope layer is obtained from Digital Terrain Model (DTM) with 10 meters resolution elaborated by the Tuscany Region, using the QGIS software. The map of slope is shown in Fig. 2a. Slope influences the surface runoff and accumulation zones and it is assumed that flat areas are more prone to flooding (Kandilioti et al., 2012).
The Copernicus programme derived product “Imperviousness 2015” with a spatial resolution of 20 m, is used to analyse imperviousness (EEA, 2015). The map of imperviousness is shown in Fig. 2b.
The characteristics of soils play a fundamental role in infiltration phenomena, depending on their texture, and therefore the percentage of silt, clay, gravel and sand present. Soils are classified by the U.S. Department Soils Conservation Service (SCS) into four main groups according to their water transmission capacity in conditions of maximum humidity (USDA, 2009). The lower the infiltration capacity, the greater the amount of surface runoff generated during rain events. The map of the hydrologic classification of soils is made by the Tuscany Region and it is shown in Fig. 2c.

The sewer density indicator is defined as the ratio between the total length of the sewer network within a census area and the extent of the census area itself. The data concerning the plan and characterization of the sewer network are provided by Publiacqua. The map of density of sewer system is shown in Fig. 2d.
Finally, social vulnerability to flood risk is assessed: the response of the population and the built environment to a disaster depends on physical, economic and social factors (Oulahen et al., 2015). For the evaluation of this index, the results of a previous study are used (Pileggi et al., 2018), in which sixteen indicators, divided into six thematic areas, are investigated: ability to react, immigration, access to resources, education, family composition, population and housing. Data for the construction of the indicators were taken from the 2011 ISTAT census and from statistical analyses carried out by the Municipality of Florence. The map of social vulnerability index to flooding is shown in Fig. 2e.

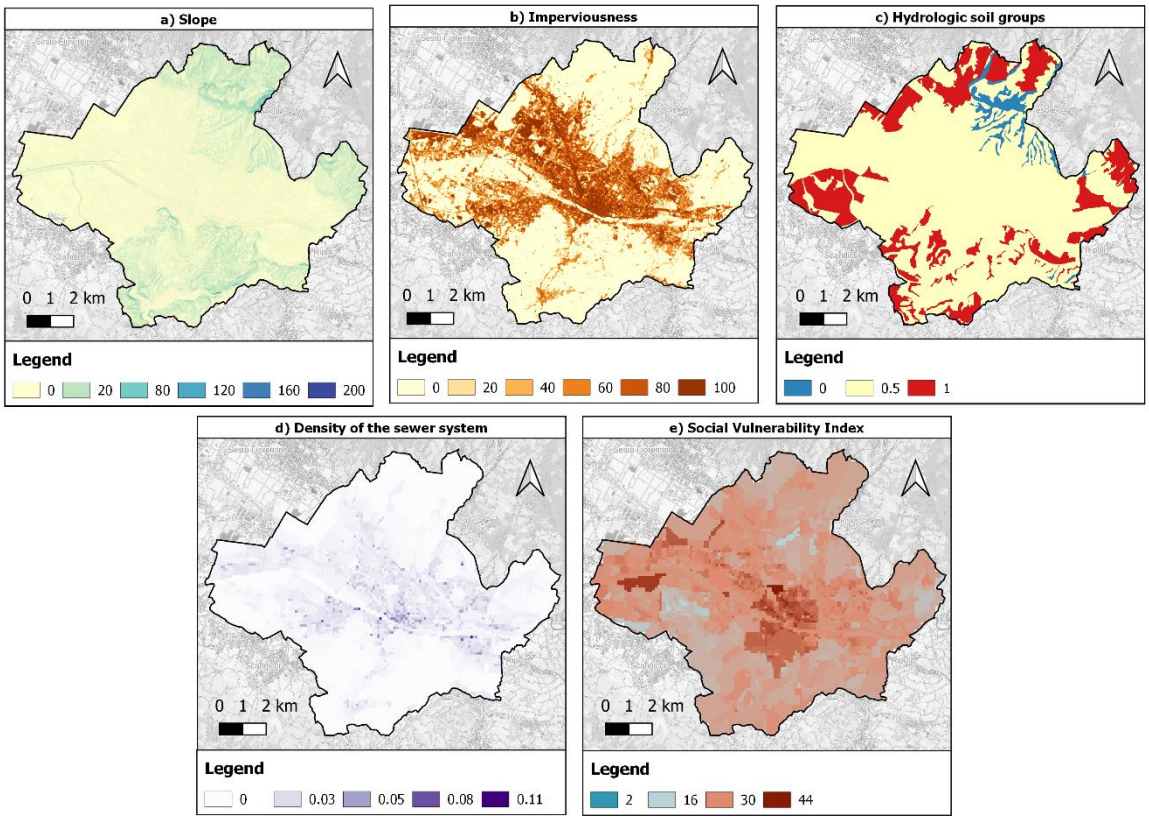

Figure 1. Indicators maps: a) slope, b) imperviousness, c) hydrologic soil groups, d) density of the sewer system, e) social vulnerability index to flooding.

Spatial Multi-Criteria Evaluation

In order to identify the areas with the highest priority in the implementation of NBS for runoff management, a Spatial Multi-Criteria Evaluation (SMCE) is used. In particular, the SMCE module of ILWIS (Integrated Land and Water Information System) software is used to define different types of criteria, according to the contribution they give to the definition of the final map, and to assign a weight to each of these criteria. The criteria are divided into benefits/costs, which respectively contribute positively and negatively to the definition of the final map, and constraints, which identify the areas excluded from the analysis.
Among the used indicators, imperviousness, social vulnerability index and hydrologic soils group are classified as “benefits” with high values identifying areas with high impermeable surface, poorly permeable soils and high social vulnerability. The slope and the density of the sewer system are instead classified as cost with low values identifying areas with a tendency to flood and collect water and a sewer system that is often inadequate for the load.
Two constraints are also defined, i.e. river areas, as areas where no intervention is required, and areas with a slope of more than 10%, where NBS cannot be correctly installed (Jiménez Ariza et al., 2019).

Since each criterion has its own scale of measurement, it is necessary to standardise them to combine them. After standardisation, the weights of each indicators were determined by Analytic Hierarchy Process (AHP) (Saaty, 1987; Kandilioti et al., 2012; Lawal et al., 2012; Gigović et al., 2017; Kazakis et al., 2015; Caprario et al., 2019; Rimba et al., 2017).

Results and discussion

The resulting map identifies the areas that need a higher priority of intervention for the installation of NBS (Fig.2). The map is characterized by values ranging from 0 to 100: zero values correspond to areas excluded from the analysis, while values from 1 to 100 indicate potentially floodable areas. The higher the value, the greater the exposure of this area to flooding.

The highest values are concentrated in the historical centre of Florence and the Rifredi and Novoli districts. Indeed, the historical centre is completely paved with very small green and blue areas. The Rifredi and Novoli districts also have large areas with high levels of imperviousness due to the dense urbanisation of the area. The obtained results are validated by comparing them with the locations of recent flooding due to pluvial extreme events, determined through archive reconstructions of such events.

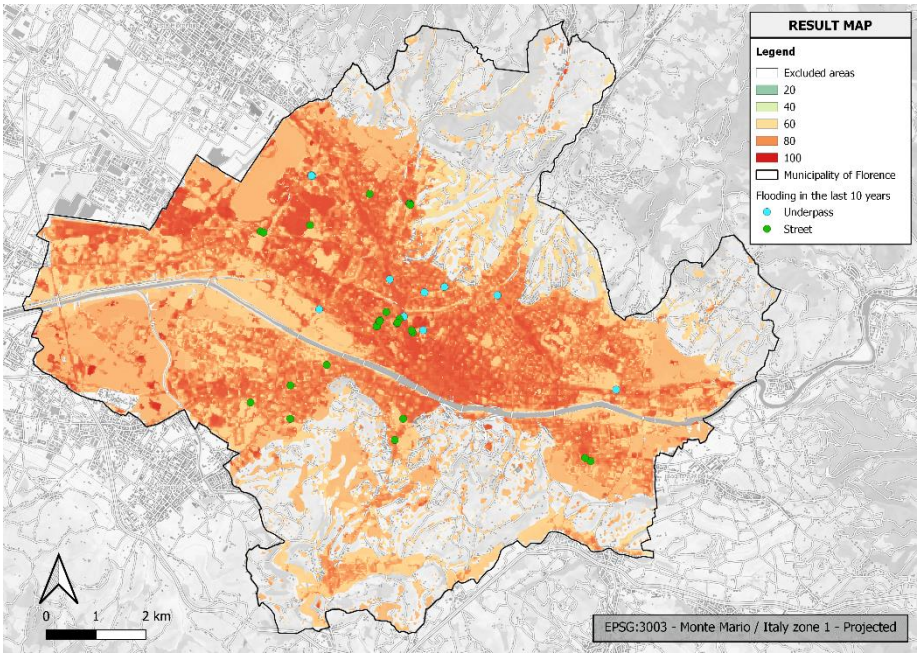

Figure 2. Results map, with values between 0 and 100. Flood events occurred in the last ten years, used to validate the results map, are shown.

Conclusions

Rainwater management in urban environments is one of today's biggest problems: classic grey solutions no longer seem to be appropriate, but solutions inspired by nature, called Nature Based Solutions, have recently widespread, with the aim of restoring the original hydrological cycle as much as possible in pre-urbanisation conditions.

The city of Florence is normally subject to urban flooding during intense rainfall events of short duration mainly due to the high share of impermeable surfaces and the insufficiency of the sewer system. A methodology is developed to identify the urban areas most prone to flooding during rain events, where the implementation of NBS could bring benefits in terms of regulating rain volumes. To identify these areas, a spatial multi-criteria evaluation was used, with environmental and social input data, such as slope, imperviousness, density of the sewer system, hydrologic soil classification and social vulnerability to flooding. These indicators were standardised and

combined, determining the individual weights on the basis of the relevant literature and excluding from the analysis areas with a slope of more than 10% and river areas due to the technical impossibility of realising NBS. The results allow identifying areas where the installation of NBS could mitigate and solve pluvial flood issues.
The map obtained can be of considerable support in territorial planning of the municipality within hydraulic risk mitigation. The same methodology can be used to assess the use of NBS for other purposes, such as reducing urban heat islands, noise or improving water quality.

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