Σχέδιο Περιβαλλοντικής Διαχείρισης Συστημάτων Συλλογής Ομβρίων Υδάτων για μη πόσιμη χρήση σε ένα Εκπαιδευτικό Ίδρυμα. Ένα καινοτόμο πρόγραμμα για την ενίσχυση της περιβαλλοντικής συνείδησης των μαθητών και της κοινωνίας.

Environmental Management Plan of Rainwater Harvesting Systems for non-potable use in an Educational Institute. An innovative project for the reinforcement of the environmental consciousness of students and society.

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Abstract: Water is the most precious and indispensable natural resource. However, water shortage is one of the largest problems in the world. Water scarcity and droughts affect negative the socioeconomic and environmental development of the areas which suffer from these phenomena. Consequently, water sustainable management is important to face the serious problem of water scarcity. Furthermore, it is commonly accepted that education for sustainable development can contribute to enhancing and ensuring the sustainable development of societies. Therefore, it is very important the suitable student's education, but also the public information and awareness, through the implementation in schools of project such as Environmental Management Plans of Rainwater Harvesting Systems for non-potable use in an Educational Institute.

Keywords: education for sustainable development, rainwater harvesting systems, water footprint, water scarcity

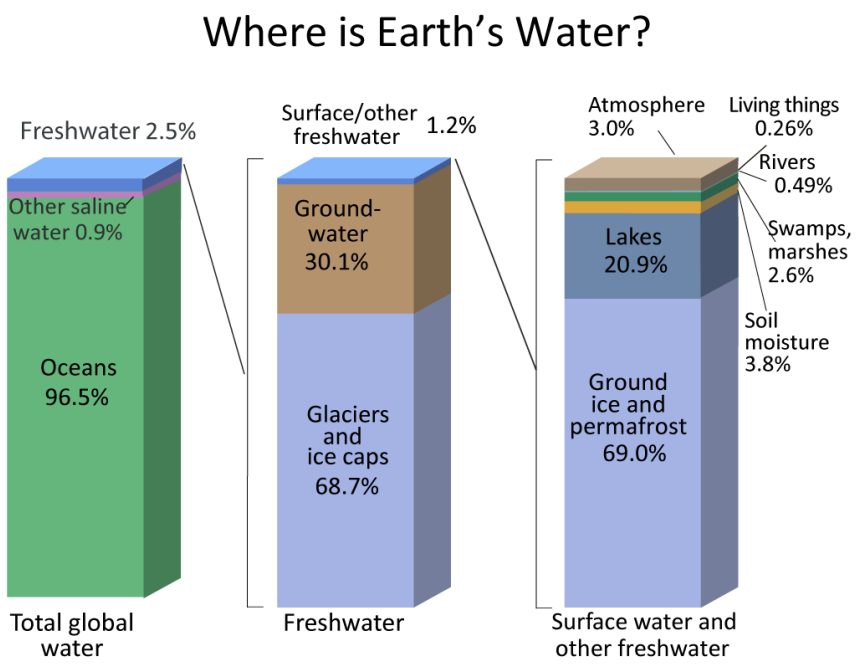
Περίληψη: Το νερό είναι ο πιο πολύτιμος και αναντικατάστατος φυσικός πόρος. Ωστόσο, η έλλειψη νερού είναι ένα από τα μεγαλύτερα προβλήματα στον κόσμο. Η λειψυδρία και η ξηρασία επηρεάζουν αρνητικά την κοινωνικοοικονομική και περιβαλλοντική ανάπτυξη των περιοχών που πλήττονται από αυτά τα φαινόμενα. Η αειφορική διαχείριση των υδάτων είναι πολύ σημαντική για την αντιμετώπιση του προβλήματος της λειψυδρίας. Επιπλέον, είναι κοινά αποδεκτό ότι η εκπαίδευση για την αειφόρο ανάπτυξη μπορεί να συμβάλει στην ενίσχυση και εξασφάλιση της βιώσιμης ανάπτυξης των κοινωνιών. Ως εκ τούτου, είναι πολύ σημαντική η κατάλληλη εκπαίδευση των μαθητών, αλλά και η ενημέρωση και ευαισθητοποίηση του κοινού, μέσω της εφαρμογής στα σχολεία σχετικών εκπαιδευτικών προγραμμάτων όπως τα Σχέδια Περιβαλλοντικής Διαχείρισης Συστημάτων Συλλογής Ομβρίων Υδάτων για μη πόσιμη χρήση σε ένα Εκπαιδευτικό Ίδρυμα.

Λέξεις κλειδιά: εκπαίδευση για την αειφόρο ανάπτυξη, συστήματα συλλογής ομβρίων υδάτων, υδατικό αποτύπωμα, λειψυδρία

Introduction

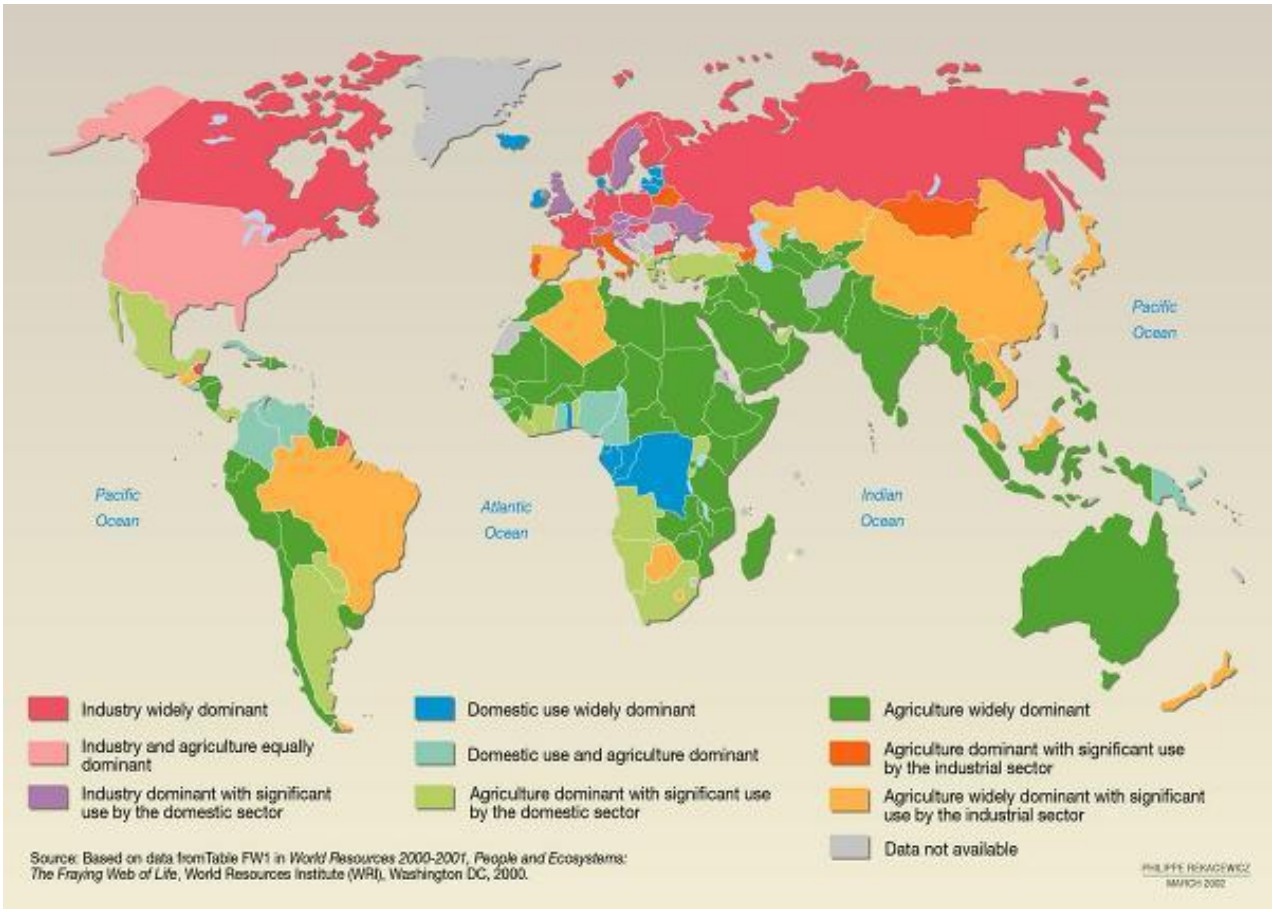
Undoubtedly, water is the most precious and indispensable natural resource. It is the source of life on earth. All species of flora and fauna consist mainly of water. The life of human is directly related to the water. About 2/3 of the human body consists of water. Pollution, contamination and lack of water are a major environmental threat of all ecosystems. However, in recent decades, human societies consume fresh water recklessly and wastefully, by considering that water reserves are inexhaustible.

Water covers more than 70% of earth's surface, but only 2.5% is fresh water because the rest 97.5% are water in oceans and other saline water, which are too salty for us to drink. However, as can be seen in the following graphic 1, even that 2.5 % of the fresh water is not all available.



Graph 1. Worldwide Distribution of Fresh Water. (Retrieved from https://www.usgs.gov/special-topic/water-science-school/science/where-earths-water?qt-science_center_objects=0#qt-science_center_objects)

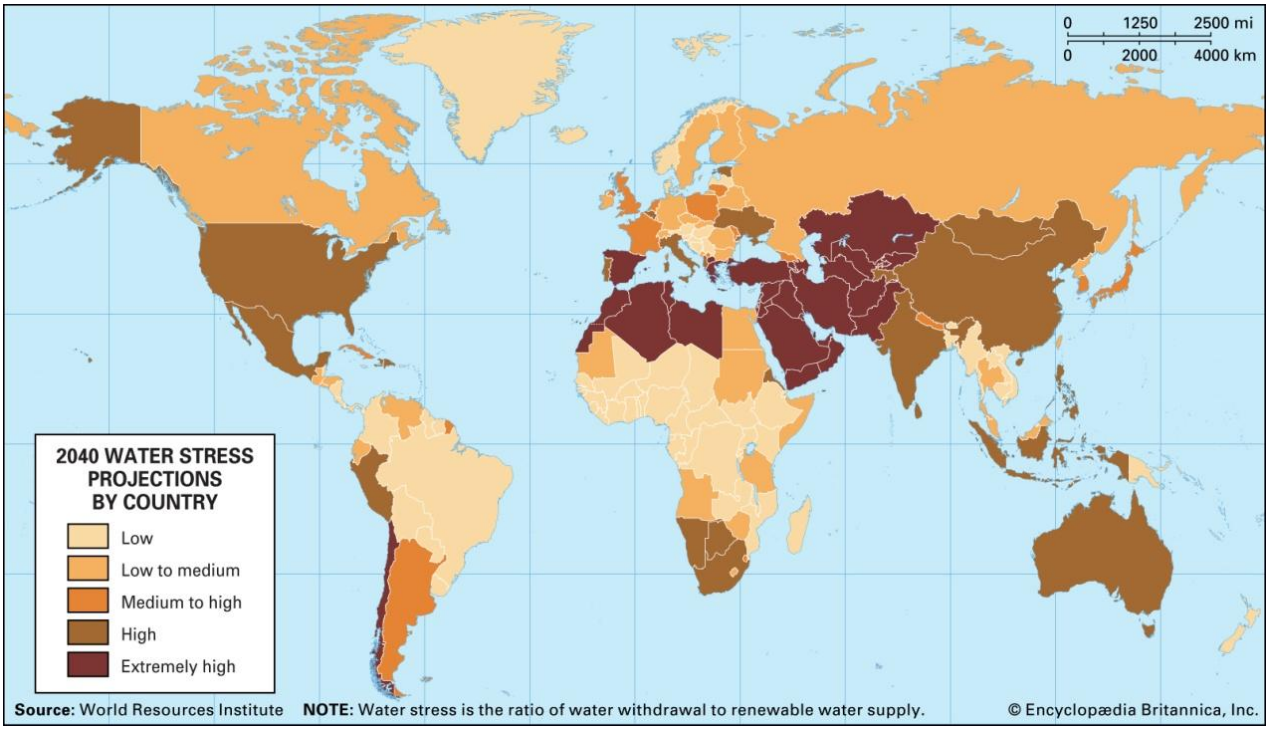
Fresh water is used for irrigation, industry, energy produce and domestic use. The distribution of water in these four activities depends on the type of development of a country. In industrialized countries, such as England and Germany, most of the available water is used to the industry. On the contrary, the countries which their agriculture based on irrigated crops, consume the most water to agriculture. Nevertheless, as can be seen in the following map 1, worldwide, irrigation holds the largest percentage of water consumption as demand for food rises with population growth.



Map 1. Major water uses by country. (Retrieved from http://www.grida.no/)

Water shortage is one of the largest problems in the world, as can be seen in the following map 2. The combination of climate change, water pollution and extremely increased water demands, due to the population growth and expansion in urbanization, industrialization and irrigated agricultural, led to deteriorate water quality and quantity.

The reckless and uncontrolled over exploitation of ground water reduced the ground water table and in some cases led to the intrusion of seawater into the aquifers, turning the fresh water in brackish. This phenomenon is more intense in areas, such as the Mediterranean, where in the summer months the water availability is extremely lower due a sharp increase in population, and therefore in the water demand, combined with a dry season.



Map 2. Global water stress in 2040. (Petruzzello)

Water scarcity and droughts affect negative the socioeconomic and environmental development of the areas which suffer from these phenomena. Climate change, less runoff (10-30%) and higher rates of evapotranspiration due to temperatures rise (in Europe could rise by 2–6°C this century) exacerbate this situation and many arid and semi-arid regions, as Mediterranean will have to address less water resources.

Consequently, water efficiency management is important to face the serious problem of water scarcity. The implementation of policies and technical measures can lead to the sustainable management of water resources. Emphasis should be given to preventive risk management policies, water pricing based on consumption, even in agriculture, as well as control and sanctions to prevent illegal water abstraction. Additional important is repair and ongoing maintenance of the public water supply network for the reduction of losses from leakage, the application of suitable irrigation water saving techniques, such as drip and groundwater irrigation, as well as preventing water consuming crops in arid areas. Furthermore, some alternative sources of water, such as rainwater harvesting (RWH), which is the process of capturing, channeling, and storing storm water runoff for later use, can be used for potable and non potable uses in order to ensure domestic water demands and contribute to the restoration of groundwater. Finally, it is very important the suitable student's education, but also the public information, awareness and active participation on sustainable management of water.

1. Description of the project

This paper presents a proposal for an educational project which aims to create an environmental management plan for the installation of a RWH system which will serve the demands for toilets and irrigation of an educational institute.

The proposal project is restricted at the study of the RWH systems for non potable use because, usually, the water demands for drinking water of an educational institute are small compared with the demands for non-potable water, which is mainly used for different purposes in various departments of the institute, such as toilets, laboratories and gardens, as well as for the cleaning of the entire building and the surrounding area. Consequently, the treatment of rainwater to produce drinking water is an unnecessary, complicated and expensive process that will increase the cost of the RWH system and may render prohibitive its application. Furthermore, the student's research will become more complex and demanding as the degree of difficulty will increase significantly.

2. Aim and purpose of the project

Rainwater harvesting is not a modern technique, on the contrary is an ancient technique, which date back more than 4,000 years in some civilizations. Unfortunately nowadays increasing number of areas encounter water scarcity and researchers estimate that by 2050 one in three people will not have access to drinking water. For this reason, scientists focus on studying the sustainable management of water resources, part of which are the methods of collecting and use rainwater.

Education for sustainable development must contribute to enhancing and ensuring the sustainable development of societies by introducing educational activities which aim at creating responsible and active citizens, critical thinking, environmentally and socially sensitive, who will take action and participate in decision making, based on the fundamental values of respect, equality, justice, solidarity and democracy.

The main aims of this project are similar to those of sustainable development education, because it focuses on the information, awareness, and participation of the students and the local society on the rational use of water and on storing rainwater, in containers, for non-potable use (toilet flushing, general cleaning, garden irrigation).

Therefore, the purpose of the project is relevant to the ultimate purpose of education for sustainable development, which is the prosperity and sustainability of human societies and natural environment. Thus, the specific purposes of the program are to protect environment, such as reduce soil erosion, augment ground water supplies and increase the water quality in the aquifers, but also to save money which could be spent for educational use.

3. Teaching methods and techniques

In general, all educational activities for sustainable development are optimally supported by a student-centered and collaborative way of teaching, such as discussion, brainstorming, workgroups, case study, role playing, simulation and interviews with experts. They are interdisciplinary, utilizing both the natural and the social sciences, such as physics, mathematics, biology, geography, sociology, history, literature, technical design, computing, etc. They also support the active participation of students and they exploit their already acquired knowledge, helping them to develop relevant scientific skills, but also fundamental horizontal skills such as collaboration, teamwork, initiative, critical thinking and environmental awareness. Furthermore, they aim at the openness of school to the society and at its involvement with the public issues. Therefore, they contribute to the cultivation of a sense of social and environmental responsibility, respect and solidarity.

Additional, educational issues, such as the one proposed, which are related to the sustainable development of the local community, are particularly attractive to students, as the learning process acquires personal interesting and a strong learning motivation for them.

Moreover, the organization and implementation of interactive local activities, which are adapted to the needs and interests of students, the local community and the natural environment, helps students to understand the value of environmental issues, their local and global impact, as well as their economic and social dimensions.

Therefore, there are many teaching methods and techniques that could be used in order to achieve the best possible application and utilization of the specific project. For example, the simulation technique and role-playing activities by students are ideal and extremely inventive. Students could take roles of the Municipal council in their area, roles of the council of a non-profit organization that deals with the protection of the environment, or roles of executives of a design and construction company. They could also be divided into small groups and each group could take roles of a different council. In this way, it is possible to apply the program to larger groups of students, as the sub-topics and the study objects would be divided into groups. They will also address the issue from a variety of different perspectives and through the process of debate and creative dialogue they will understand all the dimensions of the problem. In addition, educational visits to technical companies, environmental organizations and municipal authorities, as well as interviews with experts and municipal authorities are very important and necessary.

4. Project sub-topics

This project could be ideally studied interdisciplinary, as it is related to various scientific fields, which could be researched during various courses such as history, literature, geography, geology, mathematics, political education, high school project etc. Some of the key thematic areas that could be developed are:

4.1. Historical overview of rainwater harvesting systems

Rainwater harvesting and storage is one of the oldest methods of collecting water for domestic and agricultural purposes. It was a common technique throughout the ancient Greece, the ancient Egypt, the Roman Empire, the Byzantine Empire, India, China, Israel and many other advanced civilizations. Thus, the literature research, on historical, social, economic and environmental issues related to water use by humans, worldwide, and to the techniques that humans invented for the more efficient utilization of it, helps students to understand how essential, important and valuable good water has been for the protection and evolution of human civilization.

4.2. Modern applications of rainwater harvesting systems

Nowadays, rainwater harvesting is gaining importance again. Climate change combined with population growth on earth requires the utilization and development of all possible sources to ensure water supply. In many parts of the world, the process of rainwater collection is growing increasingly. Therefore, the bibliographic research for modern water collection applications, but also the sharing of personal experiences and the discussion help students understand the precious value of water conservation. Students understand the necessity of applying water collection methods. They gain personal motivation and interest and they feel that they are part of a global group that is interested, struggling and fighting for environmental protection and sustainable development of societies, since through their own student work, they also contribute to the improvement of their local community.

4.3. The water footprint of a country

This subsection is about the water footprint of a country which is the quantity of water consumed by the people of a country for the production of the goods and services. Relevant and very useful is also the research on the distribution of fresh water in the four basic activities, which are the irrigation, the energy produce, the industry and the domestic use. Through this subsection, students realize the environmental, social and economic value of water. They understand the consequences of human activity on freshwater reserves, and they cultivate their ecological consciousness. An educational visit to the relevant departments, such as the Water Service and the Department of Environment and Hydroeconomy, is particularly interesting, because there the students can look for their local water footprint and the potential environmental impacts.

4.4. Study of the water policy, worldwide and in their country

The awareness and active involvement of students increase as students search and find out the worldwide measures and policy tools against water scarcity and pollution, and their country

legislation and measures for mandatory collection of rainwater, especially, in some highly arid regions of their country.

4.5. Study of the hydrogeological conditions of their country and especially of their region

Students study and research the geomorphological structure of their country and in particular of their region, as well the surface and underground water resources. Following, students can combine their findings for the hydrogeomorphology of their area and for its water footprint, and they will be able to understand the reasons why only a small portion of this water potential is economically and technically usable, resulting in water deficiency problems in some areas for specific time periods.

4.6. Study of the climatic conditions of their country and especially of their region

Students study the position and the topography of their country and they research how these are related with the climate, the main seasons and the distribution of rainfalls throw their country. Particularly interesting, but also necessary for the implementation of the project, is the collection of meteorological data for their area, as well as the creation of the ombrothermic diagram, so that they can identify the dry and hot periods. The meteorological data can be obtained either from a station set up at the school or through an educational visit to a relevant department, where specialist scientists can explain the operation of a meteorological station and provide the required data.

4.7. Benefits and inhibit factors for the development of the rainwater harvesting systems

Students understand the utility of the RWH systems and the barriers that must be accessed, as it take place bibliographic research, brainstorming and discussion about the advantages and the disadvantages, the benefits and the barriers of a RWH system.

4.8. Rainwater harvesting system components

Students look for the different types of RWH systems and the parts they consist of. They also study their operation and maintenance.

4.9. Implementing a rainwater harvesting system at the school

Working in groups, students, assisted by their teachers, search for information about their school building and the surrounding area.

- They calculate the total and the roof surface of the building, as well as the surrounding area of the yard, either from the building designs or from free digital applications.
- They record the ways in which water is consumed for non-potable use inside the school, by working in the field. So, for example, they can record, on a rough draft, how many toilets there are in the school, the green area and the vegetation types of the school yard.
- Continuing the field work, they record the vertical gutters and they mark them on a copy of the floor plan of the roof. Then, in the classroom, students observe carefully the slopes on the floorplan of the roof, and they divide its surface to sections that drain the rainwater in each gutter.
- They draw by hand or in digital software precise floor plans of the building and the yard of the school, on which they place the water consumption areas, the gutters, the roof slopes and other useful information.
- They search for relevant surveys from which they use the data for the water consumption per person per day, as well as for irrigation per day. They can also be informed of the annual water consumption in the building and the number of people serving the building, from the school administration. Consequently, combining these water consumption data, they can calculate the monthly water needs throughout the year, as well as the amount of water used for humans and for irrigation.
- Furthermore, they can count the monthly runoff volume for each section of the roof of the building, using the meteorological data of the region and the floor plans of the roof.
- Next, they can analyze and compare for each month the drainage volume of water that can be collected by the total area of the roof of the building and the total required amount of water for the needs of the institute. In this way, students can extract important conclusions regarding the utility and efficiency of the collection system.
- The sizing of the tank is also one of the most important steps of the study. The student team, assisted by a qualified teacher, may choose one of several methods for sizing the tank.
- Additional, students choose the number, the material and the shape of the storage tank but also their possible locations taking into account both the safety of construction and its financial cost and aesthetic appearance. Afterwards, they can add the possible location of the proposed tanks to the floor plan of the building and the school yard that they already designed.
- It is also necessary to do a research and then a proposal on the maintenance of the storage tank and on water treatment methods, to avoid possible health problems.
- Finally, it is very important to make a cost analysis of RWH systems, so that students understand not only the environmental but also the financial benefits of them.

Expected results

The implementation of a RWH system in an educational institute is an ideal opportunity for ecological awakening of students of the institution, but also the entire society of the total

community. The students of the institution, assisted by qualified teachers, can take an active role in the implementation study, the construction, the maintenance, the cleaning and the proper functioning of the roof and the components of the RWH system. It will also be very useful to record the consumption of rainwater and municipal water supply from the building and create information brochures for the citizens of the city or even to organize informative conferences.

Moreover, the public city water supply system will benefit because of the high discharge of the network from the large amount of water consumed by the institution. Thus, the damages of the network will be reduced, as well as the maintenance costs.

Nevertheless, it should not underestimate the environmental benefits arising from the application of the RWH system, which cannot be estimated at financial units.

In conclusion, RWH systems are not yet widespread but soon they will be necessary in much more areas because water scarcity is a worldwide threat and water harvesting will provide a lot of environmental and socioeconomic benefits for the countries and the citizens and a sustainable living for the future societies. Consequently it is essential for teachers to create projects for the installation of RWH systems in schools in order to educate students about the principles of water conservation and addressing the challenge of water scarcity facing the world.

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