Journal of Sustainability Perspectives 3(2), 2023, 148-155

Journal of Sustainability Perspectives

journal homepage: https://ejournal2.undip.ac.id/index.php/jsp/

Harnessing Sustainable Water Management through Innovation and Efficiency at ESPOCH

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Article Info

Received:
23 May 2023
Accepted:
15 September 2023
Published:
30 September 2023

DOI:
10.14710/jsp.2023.20566

Presented in the 9th International Workshop on UI GreenMetric World University Rankings (IWGM 2023)

Abstract. ESPOCH, an Ecuadorian university with a unique underground water source, is developing a drinking water plant to serve its population of over 22,000 students and staff members. The paper explores innovative measures and technology for efficient water utilization at ESPOCH, including a secondary, untreated water line for non-potable uses and the adoption of smart water management technologies to monitor and regulate water consumption. This approach addresses the provision of safe drinking water, plastic waste reduction, and health risks linked to poor water quality. ESPOCH's innovative water management approach contributes to the broader discussion on sustainable universities' role in managing water resources. The study highlights the importance of technology and innovation in resource conservation and utilization in higher education institutions, with ESPOCH serving as a valuable example for other universities addressing water scarcity, environmental impact, and promoting sustainable practices.

Keyword:

Sustainable Water Management, Sustainable Universities, Smart Water Management, ESPOCH

1. Introduction

The role of universities worldwide in attaining the sustainable development goals (SDGs) is essential, as they are the institutions responsible for preparing future professionals, conducting meaningful research, and engaging with the community to promote sustainable development [1]. Universities have the power to contribute significantly to the achievement of the SDGs through education, research, and operations [2].

Universities can promote sustainability through their research, teaching, and institutional footprints, but more initiatives are necessary to create a significant impact [3]. The role of universities in achieving the SDGs, includes at least five specific roles that can be addressed: educating and training future leaders, generating knowledge, creating innovative solutions, providing policy advice, and engaging with the broader community [4].

Universities worldwide are increasingly recognizing the importance of contributing to sustainable development and addressing global challenges, such as water management [5]. As neutral conveners and assemblers of talent, universities are uniquely positioned to address sustainable water management by conducting research, educating future professionals, and fostering collaboration between various stakeholders.

Universities can also contribute to sustainable water management by developing their campuses as living laboratories for sustainability, implementing innovative water management solutions, and sharing best practices with other institutions [6], [7]. Moreover, important actions for instituting net zero emissions and aligning university operations with water conservation, include: providing free drinking water for students, staff, and visitors and developing management and guardianship plans for on-campus and surrounding waterways [4].

Escuela Superior Politecnica de Chimborazo (ESPOCH) is a higher education institution located in Riobamba, Ecuador, that offers 44 academic undergraduate programs in seven colleges at its main campus in Riobamba, Ecuador [8]. Since the university has its own water supply from underground wells, it is essential to consider innovative measures and technologies for efficient water use to ensure sustainable water management on campus.

A novel approach for the drinking water plant to be built at ESPOCH's main campus in Riobamba is using dual water systems, where one network supplies potable water for drinking use, while the other supplies non-potable water for landscape irrigation and other purposes. These systems can boost water supplies by lessening the burden on drinking water systems, as they do not have to provide water treated to drinking water standards for activities such as toilet flushing, firefighting, street cleaning, and irrigating ornamental gardens or lawns [9], [10].

In this work, the study for implementing a dual water system at ESPOCH is presented. The university can expect potential benefits, such as more efficient use of water resources, cost savings, and increased environmental sustainability. However, the university must also carefully consider the increased complexity of managing a dual water system and respond appropriately to prevent cross-contamination between potable and non-potable water supplies.

2. Results

2.1. Study Site

Escuela Superior Politécnica de Chimborazo is a Higher Education institution in Central Ecuador at an altitude of 2,754 masl, as the city is near the equatorial line, its climate is cool and overcast with temperatures ranging between 14 °C and 23 °C all year round.

ESPOCH stands out with its unique underground water source which has served it from its very foundation in 1972. A drinking water plant, backed by the city council, is being developed to cater to the university's population of over 21,000 students and 1,000 staff members. A key strategy is implementing a secondary, untreated water line for non-potable uses like plant irrigation and washroom flushing, a map of the colleges and university areas which add up to 120 hectares can be seen in Figure 1.

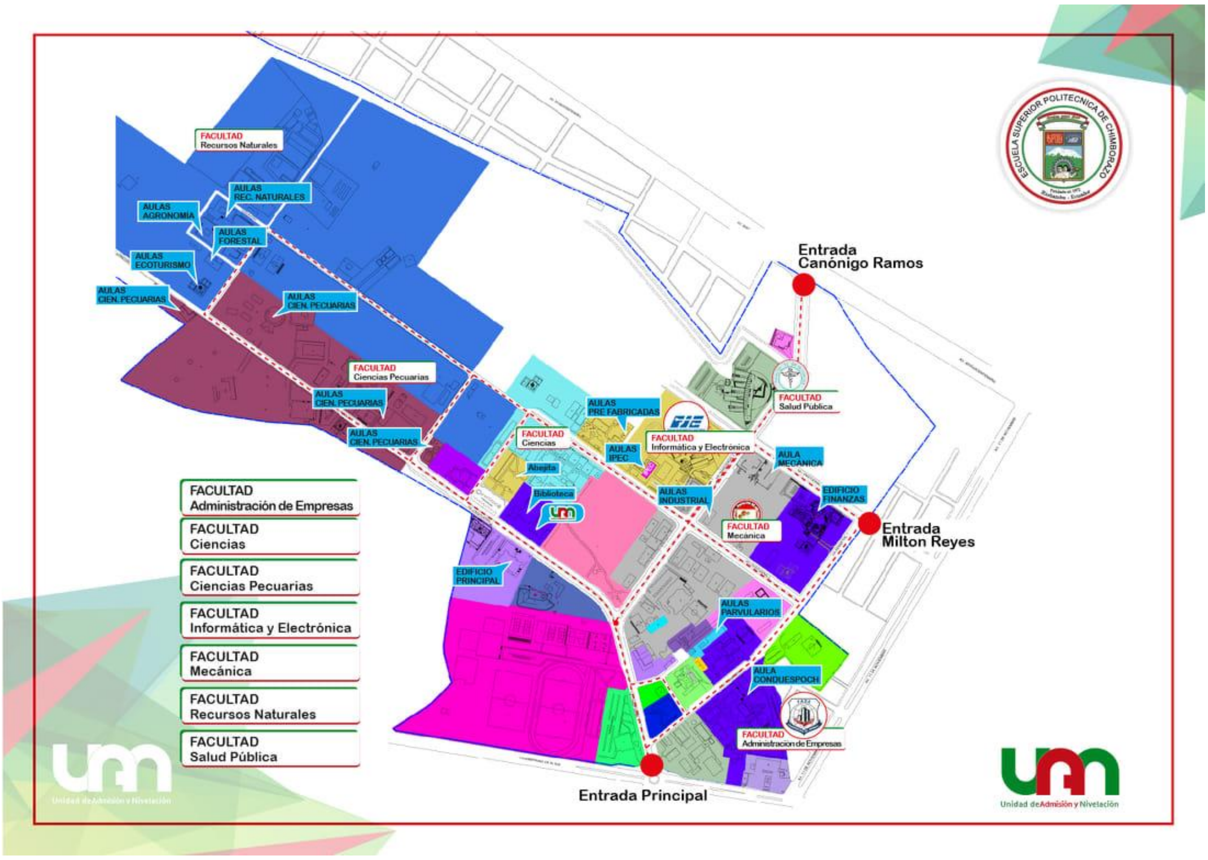

Figure 1. Map of ESPOCH including its colleges

2.2. Water Quality Assessment

The water analysis of ESPOCH's underground water samples revealed the following composition: Aluminium at 0.25 mg/L, iron at 0.11 mg/L, lead levels below the detection limit of 0.005 mg/L, total hardness at 558 mg/L, chemical oxygen demand (COD) below 30 mg/L, and a pH of 7.30, indicating near-neutral conditions.

To treat the underground water for consumption, the water treatment plant at ESPOCH will use a comprehensive treatment process consisting of filtration, reverse osmosis (RO), and control systems. The proposed water treatment plant to be installed at ESPOCH is a CK-RO-5000 L (SUS304) One stage Reverse Osmosis (RO) water equipment system. The system is showed in Figure 2:

Figure 2. Proposed water treatment plant for ESPOCH

The sand and carbon filters will effectively eliminate suspended particles, organic matter, and trace metal contaminants such as aluminium and iron. The RO system, which boasts a desalination rate of 96-99%, will address the total hardness and further reduce the presence of residual contaminants. Lastly, the electronic control system will continuously check and keep water quality parameters within the desired ranges. Among the most important parts of the system, we have:

- Raw water tank (10-20 m^3) made of PE Antiseptic material, featuring a stainless-steel inlet float valve and a water level controller.
- Raw water pump (CHL8-40 SS304) with a flow of 9.0 m^3/h and a head of 30 m.
- Sand filter ϕ900 × 1850 mm, including an SUS304 tank, an automatic valve, and top & bottom water distributor.
- Carbon filter ϕ900 × 1850 mm, with similar components as the sand filter.
- Scale inhibition dosing system, including a dosing tank (40L) and a chemical (25L).
- 5µm Cartridge filter, featuring a CK-30''*7core material, and 7pcs of 30″×5 µm PP filters.
- High-pressure pump (CDL8-12) with a flow of 9.0 m^3/h and a head of 102 m.
- Reverse osmosis water production system, with a production rate of 5 m^3/h and a desalination rate of 96-99%. Components include membrane housing, membrane elements, stainless steel frame, solenoid valves, and flow control valves.

This water treatment plant uses a combination of filtration, RO membrane, and control systems to treat water effectively, achieving an elevated level of desalination and producing high-quality water for various applications.

3. Discussions

3.1. Water Requirements for Crop Irrigation

The amount of water needed for crop irrigation depends on climate, crop type, and soil conditions. Crop water requirements (CWR) refer to the amount of water needed to compensate for evapotranspiration losses from a cropped field during a specific period [11]. The crop water need (ET crop) is defined as the depth (or amount) of water needed to meet the water loss through evapotranspiration. For example, the total water need of tomatoes over the entire growing season is 786 mm, of which 68 mm is supplied by rainfall, and the remaining 718 mm needs to be supplied by irrigation [12].

Efficient irrigation practices can reduce the volume of water applied to agricultural fields by 30-70% and can increase crop yields by 20-90% [13]. Smart irrigation systems use artificial intelligence techniques and advanced sensors to perfect water use in urban and rural agriculture for soil crops. Drip irrigation, a modern type of irrigation system, involves the slow application of water and sometimes fertilizer directly into the soil through a system of small-diameter plastic pipes with built-in outlets called emitters or drippers. This method is more water-efficient than traditional watering techniques, but smart irrigation systems can further enhance the efficiency of drip irrigation by monitoring and adjusting water use based on real-time data [14].

ESPOCH has a total area on campus covered in planted vegetation of 96,900 m2 which equals to 9.69 Ha. Students use agricultural plots for experimenting novel agricultural practices including planting crops such as corn, potatoes, and tomatoes. For corn, high yielding varieties generally require 22 to 30 inches of water per year, which in terms of area, a 10 x 10 ft area of corn requires around 60 gallons (225 litres) of water per week or almost 6,000 m3/year [15]. In the case of potatoes, the water requirement is in between 3,000 to 4,000 m3/year [16].

For watering the crops that are planted in the main campus at ESPOCH, with a conservative scenario, it must have about 30,000 m3/year of water. If we use treated water for this purpose, the costs for the university will skyrocket. Two studies suggest that feasible costs for brackish water treatment using RO technology would be $0.6/m3 [17], [18]. This means using a single distribution system would have an added conservative cost of US 18,000 on top of the unnecessary nature of using potable water for agriculture or non-drinking uses.

3.2. Water Requirements for the campus population

According to the Penn State Extension, people generally use 50 to 100 gallons of water per person per day in their homes [19]. In emergency situations, the World Health Organization (WHO) recommends a minimum of 15 litres per person per day, with a higher quantity of about 20 litres per person per day to account for basic hygiene needs and food hygiene [20].

According to the U.S. National Academies of Sciences, Engineering, and Medicine, an adequate daily fluid intake is about 15.5 cups (3.7 litres) of fluids a day for men and about 11.5 cups (2.7 litres) of fluids a day for women. These recommendations cover fluids from water, other beverages, and food [21].

According to the literature review, for supplying at least 3.7 litres of drinking water per day for the campus population amounting to 22,000 people, a total of 81.4 m3/day of drinking water will need to be produced. It means that the drinking water plant will run at full capacity during 16 h/day giving it time enough to conduct daily maintenance activities.

Moreover, there is no other feasible option to provide drinking water to the campus population than having a dual system installed for the campus, it means a better use of resources and potential savings and environmental benefits when people use reusable bottles for refilling water for free at the campus instead of buying water with disposable bottles (which nowadays is the usual).

3.3. Installation of a dual water system at ESPOCH

Implementing a dual water system at ESPOCH can provide a range of benefits, including the efficient use of water resources, cost savings, and reduced burden on the potable water supply. However, there are also drawbacks to consider, such as the complexity of the infrastructure and the potential for cross-contamination.

From an economic perspective, the dual water system can result in significant cost savings for ESPOCH. By encouraging students and staff to use reusable bottles and refill them with free potable water at campus, the campus can reduce the demand for disposable bottled water. This, in turn, can lead to reduced expenses on buying bottled water, waste disposal, and waste management.

Implementing a dual water system at ESPOCH is essential for ensuring the efficient and sustainable use of water resources. By prioritizing a dual water system, the campus can supply an example for other institutions and communities to follow, ultimately contributing to the broader goal of sustainable water management.

3. Concluding remarks

Efficient resource use, potential cost savings, and environmental benefits were identified as the primary reasons for adopting such a system. These findings have significant implications for water management at ESPOCH, as they emphasize the need to prioritize sustainable practices in the face of increasing water scarcity and environmental challenges.

The importance of technology and innovation in resource conservation and use cannot be overstated, particularly in higher education institutions. By embracing innovative water management solutions, such as dual water systems, universities like ESPOCH can prove their commitment to environmental stewardship and set a positive example for students, faculty, and the broader community.

ESPOCH can serve as a valuable model for other universities addressing water scarcity, environmental impact, and promoting sustainable practices. By successfully implementing a dual water system, it can inspire other institutions to adopt similar measures and contribute to a more sustainable future.

Knowledge sharing and cooperation among universities play a critical role in promoting sustainability, UI GreenMetric World University Rankings presents and ideal platform for this kind of collaboration. By sharing their experiences, best practices, and lessons learned, institutions like ESPOCH can help accelerate the transition to more sustainable water management practices across the higher education sector.

Future work in this area should focus on evaluating the performance of dual water systems in various settings and finding other opportunities for improving water management practices. Additionally, research should be conducted to explore innovative technologies and strategies that can further enhance the sustainability of water use in higher education institutions.

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