PROMOTING SUSTAINABILITY IN EDUCATION THROUGH THE IMPLEMENTATION OF GREEN WALLS FOR GREYWATER TREATMENT

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ABSTRACT

This study describes the methodology followed to design, build and operate a pilot green wall treating greywater from a vocational training center. The study was carried out in the framework of a master thesis in Environmental Engineering carried out in collaboration with the vocational training center where the pilot system was built. The system consisted of several pots arranged in rows planted with different species of macrophytes. Results showed a successful removal efficiency of the main pollutants (total solids and organic matter), while further post-treatment would be needed to reduce turbidity and pathogens in order to fulfill water reuse standards. This work shows how teaching in certain engineering studies can focus on sustainability and perform a practical work involving younger students from a vocational training center.

1 INTRODUCTION

1.1. Background and motivation

Green walls are Nature Based Solutions (NBS) able to provide several benefits such as greening, CO_2 trapping, O_2 production, climate regulator, and household insulation. In addition, they are able to minimize wastewater treatment footprint and to provide an onsite solution and a local source of reclaimed water. This technology responds to Sustainable Development Goals 6, 11, 13, 14. However, green walls have only been

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used for wastewater treatment in a few specific cases [1, 2] and treatment efficiency still needs to be further proven and optimized before the massive implementation of this technology.

The study consisted in designing and building a pilot plant for the treatment of greywater by phytoremediation in a vocational training center with about 1,000 students, located in Barcelona.

The study was carried out in the framework of a master thesis in Environmental Engineering at the Universitat Politècnica de Catalunya. This included dimensioning, design, set-up, operation and monitoring of the pilot plant. The students from the center were involved in the design, in charge of the construction and actively participated in the operation of the system.

The Center, as a Green School, promotes activities with two objectives: (1) to raise students' awareness of the importance of their carbon footprint, and (2) to use training activities that promote good practices within their profession, encouraging respect for the ecosystem and the fight against climate change.

At the curricular level, the project was developed in the 2nd year of the course on Gardening and Floristry. This is a synthesis and consolidation of the modules related to gardening and plant nursery, and the transversal modules studied throughout the degree.

1.2. Objectives

The main educational objectives of the study were: (i) to consolidate the learning outcomes achieved throughout the course; (ii) to experiment new ways of treating and reusing wastewater for irrigation; (iii) to implement a scientific research through the design, construction and evaluation of a pilot plant; and (iv) to participate in a real and relevant professional context for the Gardening and Floristry sector while promoting the transfer of knowledge between vocational training and the university.

Regarding the research objective, the main goal was to test the feasibility of greywater treatment in a vertical garden at pilot scale, in order to assess the treatment efficiency and the possibility of generating a local source of reclaimed water.

2 METHODOLOGY

The project was based on learning through active methodologies. The most important aspects of the teaching methodology were:

- The challenge of the project was fully contextualized in the reality of the school and in the professional reality of the degree.
- The students worked in self-managed groups with puzzle methodology and specific roles to design the prototype of the pilot plant.
- Each phase of the project presented activities that contained research elements that students, with the support of the teacher, must solve.
- Cooperative teamwork was evident in all phases of the project.

- Diversity was taken into account as students could work at different paces and present prototypes and projects with multiple possibilities, depending on their interests and skills.
- The staff of the university introduced the scientific method in the project and at the same time, positively encouraged students.
- The designs and projects created were shared with the group, looking for spaces and activities. This helped students to contrast ideas, include improvements, and generate new ideas.
- Both co-assessment and student self-assessment had been included, especially with regard to teamwork, oral communication, student autonomy and initiative.

The project required a dedication of 86 teaching hours, spread over 14 weeks, and was divided into the following five phases:

Phase 1. Presentation of the project (challenge) and student's theoretical training, during the first sessions of the module, students received theoretical training on the specific topics and contents of phytoremediation and vertical gardening.

Phase 2. Design of the pilot plant by groups (3-4 people) under the leadership and advice of the university staff. The puzzle learning technique was used in this phase; the roles of responsibility encompass the main areas of work of the project in order to present a prototype to the class. The university advised and evaluated the proposals. From this process, the prototype that best suited the needs of the project was selected. The prototype was designed emulating a 3-step subsurface vertical flow wetland (Figure 1). The system was organized in three rows and four columns. The influent wastewater (greywater from the sinks of the toilets of the center, dosed with primary sludge of a wastewater treatment plant) was fed by drop irrigation pipes on the top row and then percolated vertically through the rows of pots. This configuration enhances oxygenation, hence improving treatment performance. Different substrate materials were tested in the different columns (two columns with mineral and the two others with organic substrate), dividing the system in 2 modules working in parallel.

Phase 3. Construction of the pilot plant, the whole class group worked collaboratively to build the pilot plant (Figure 1).

Phase 4. Commissioning and monitoring of the pilot plant, the pilot plant was started up and then operated and monitored for one month. Samples of the influent and effluent water were took by the students twice a week and transported to the university where the master student performed the lab analysis in order to evaluate the performance of the vertical garden in terms of organic matter, suspended solids, turbidity, pathogens and nutrients removal.

Phase 5. Drafting of a vertical garden to treat the waters of the sink of the center. With the results obtained during the pilot study (loads, retention time, plant species, substrates, efficiency, etc.), the students designed a full-scale vertical garden capable of treating the greywater from the sinks of all the toilets of the center.

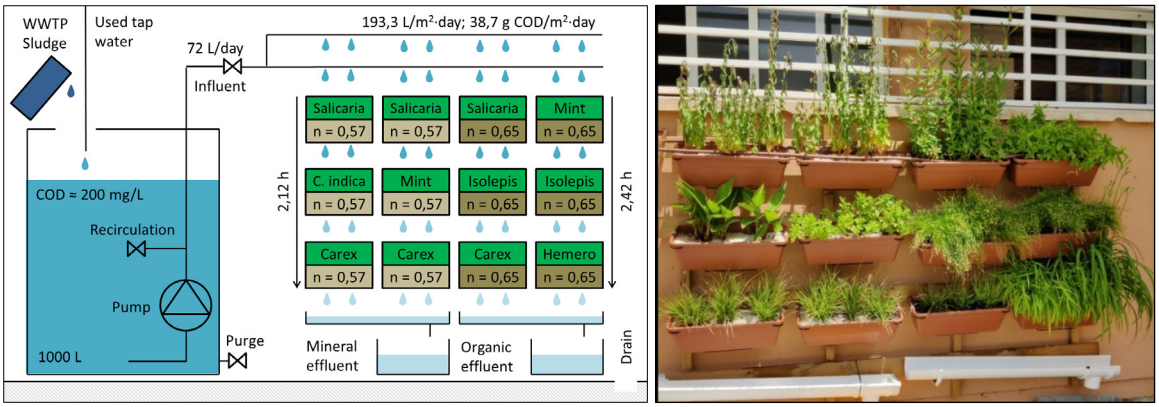

Figure 1. Scheme of the pilot plant (left) and picture of the vertical garden (right)

3 RESULTS AND CONCLUSIONS

The prototype was designed, built and operated and monitored according to the methodology described above. Overall, the expected performance was achieved in terms of wastewater treatment, achieving suitable removal of pollutants (>60% removal of total solids and organic matter), while further post-treatment would be needed to fulfill water reuse standards (turbidity and pathogens).

Moreover, this methodology and this study can be used to respond to different Sustainable Developing Goals. Indeed, nature-based solution applied in the field of wastewater treatment are directly linked with SDG6 (clean water and sanitation) and SDG14 (life below water). Green walls are also a suitable solution for cities, contributing to SDG11 (sustainable cities and communities). Finally, considering the positive effect of green walls in terms of CO_2 trapping, O_2 production and water sanitation, also SDG13 (climate action) is addressed.

Concerning students' experience and participation, a reduction of school absenteeism was observed compared to data from previous academic years. Phases 3 and 4 of the project (construction and monitoring, respectively) were the most motivating activities for students and had the best learning results. These also prepared their problem-solving capability to later develop a full-scale vertical garden project.

This work shows how teaching in certain studies as civil engineering, architecture, and environmental engineering can focus on sustainability and SDGs, performing a practical work involving younger students from a vocational training center.

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