Experimental protocol

Constructed wetlands: How to make a small scale Nature-based Wastewater Treatment Plant

Theoretical Framework

Constructed wetlands (CWs) are nature-based solutions that can be used as an alternative or as a complement to traditional wastewater treatment systems. These artificial systems are designed to mimic natural wetlands, relying on the interactions among plants, microorganisms, and substrate for the removal of wastewater contaminants.

The main processes that occur in CWs are phytoremediation (removal/accumulation of pollutants by plant roots), bioremediation (degradation of organic pollutants by microorganisms), and filtration (physical-chemical interactions with the substrate/soil, including sorption processes).

CWs can be used to remove nutrients (nitrogen and phosphorous), organic matter, microorganisms (e.g., fecal coliforms), metals (e.g., copper, zinc, cadmium, lead), hydrocarbons (e.g., polycyclic aromatic hydrocarbons found in petroleum), nanoparticles (e.g., silver nanoparticles), and pharmaceuticals (e.g., antibiotics), among others.

CWs can be applied to various types of contaminated waters, such as urban wastewater, livestock effluents, aquaculture effluents, agricultural runoff, and industrial wastewater.

The main advantages of CWs include being a sustainable water treatment, using environmentally friendly processes, having a low operating cost, possible integration into the landscape, and being a green technology.

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Objectives

This activity aims to highlight the advantages and applications of CWs. Through this activity, students will be able to build a small scale model of a CWs, understand how it works, and learn about the physical and biochemical processes inherent to its operation. The concept of green technologies will also be addressed. This protocol is included in the Curricular Areas of Physio-Chemical Sciences (7th grade), Natural Sciences (8th grade), Geography (9th grade) of the 3rd Cycle of Basic Education, and in the Curricular Areas of Biology and Geology (1st grade) and Biology (12th grade) of Secondary Education.

Material

- 3 Transparent boxes with a volume of about 10L or 20L (depending on the size of the plant)
- 3 Perforated silicone tubes, each with the length of the box and with a diameter large enough to fit the tap
- 3 Taps
- Scissors
- X-acto
- Ballast or gravel
- Expanded clay (e.g. Leca) or other porous material (e.g. lava rock)
- Sand
- Plants (e.g. lilies or pitchers)
- Water

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Procedimento

1. Drill a hole in the base of the 3 boxes to fit the tap. Insert the silicone tube that must be previously perforated, along the length of the entire box, with the tap at the exit of the hole (Figure 1).

Figure 1: Assembled box with the tube and the tap**.**

2. In each box, place enough gravel to make a layer of ca. 4 cm covering the silicone tube (Figure 2).

Figure 2: Assembled box with a layer of gravel.

3. Then, put enough expanded clay or lava rock or other porous material in each box to make a layer of ca. 4 cm (Figure 3).

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Figure 3: Assembled box with a layer of lava rock on top of the gravel layer.

4. Place the plants inside each box.
5. Completely cover the roots and the entire underground parts of the plants with a layer of sand (ca. 16 cm).
6. Add a nutrient solution. The volume of the solution should be enough to soak the entire substrate, but no water should remain on the surface. Renew the nutrient solution every other day for a week so that the plants are completely adapted to the new system. The solution should be placed on top evenly over the entire surface. To remove the solution, open the tap at the bottom of the box.
7. The system is now ready to receive contaminated water for treatment.
8. To monitor the treatment of the contaminated water: 1) select the parameter under study, 2) measure this parameter in the contaminated water, 3) add contaminated water to the system. The water should always be placed on top evenly over the entire surface, the volume should be sufficient to soak the entire substrate, but no water should remain on the surface; 4) take aliquots of water from the system by opening the tap at the bottom of the box periodically over a week; 5) measure the parameter under study in the aliquots of treated water. From this data stipulate the required treatment time in the system (usually one week). Whenever necessary add distilled water throughout the week to keep the system soaked. 6) After treatment, remove all the water from the system through the tap placed at the bottom.
9. The system is ready to receive contaminated water again for treatment.

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Results report

1. State the working hypothesis on which the concept of CWs functioning is based on.

2. What is the plants role in CWs?

3. Who is responsible for the degradation of organic pollutants? What is this process called?

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4. What is the reason for the use, in the system, of different substrates with different characteristics?

5. What are the main advantages of using CWs?

6. Why is a CW considered a Green Technology?

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