Center for Environmental Studies
Summer Research Proposal 2009
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Use of Aquatic Plants as a Sustainable Waste Water Treatment Method in Developing Countries

Abstract

Developing countries often have no method of waste water treatment, which results in the contamination of local water supplies, leading to illness and death. A large problem with most waste water treatment systems is the cost of upkeep. Residents of developing countries often cannot afford the cost of chemicals commonly used to treat waste water. Because of this, significant research has been done showing that the use of some aquatic plants is successful in treating waste water. It would decrease the cost and increase the sustainability of a waste water treatment system if the plants used thrived in the immediate environment. Therefore, this research project will focus on the discovery of new aquatic plants that can be used to treat waste water. The availability, effectiveness relative to plants previously studied for this purpose, and safety concerns for the local residents will be taken into account.

Proposed Research

This research will start on May 25th, 2009 and will last 10 weeks. The central purpose of this research is to determine the effectiveness of aquatic plants that can be used to treat waste water. One of the most deadly pollutants in waste water is heavy metals. Waste water could be made safe to drink by filtering it and killing the bacteria in it, but the heavy metals present in all waste water make that impossible. When dissolved in water, heavy metals exist as ions. In the hydroponic growth of plants, ion transport across the membranes of the cells in the roots is essential to plant growth. The cells in the roots use ATP to pump H^+ out of the cell, creating a proton gradient. The positively charged ions of the heavy metals are then free to cross the membrane through membrane proteins[1]. Research has shown that some aquatic plants like duckweed and water hyacinth can be used to absorb heavy metals in waste water[2]. However, these plants are not available throughout the world. It is important to find new plants that can be used for this purpose in order to spread this technique to other parts of the developing world. Therefore, the research will focus on the use of hearty, invasive, and fast-growing aquatic plants that could be used to absorb heavy metals from water.

It has been found that the some common toxic heavy metals in waste water are Aluminum, Arsenic, and Lead. These heavy metals are generally found in waste water in the following amounts:

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[1] Swamy, G. S. "How Do Plants Absorb Nutrients from the Soil? Study of Nutrient Uptake." Resonance (1998): 45-58.

[2] Bdour, Ahmed N., Moshrik R. Hamdi, and Zeyad Tarawneh. "Perspectives on Sustainable Wastewater Treatment Technologies and Reuse Options in the Urban Areas of the Mediterranean Region." Desalination 237 (2009): 162-74.

Metal	Ion Form	Amount Present in Waste Water[3]	Amount Acceptable in Drinking Water[4]
Aluminum	Al^{+3}	15 ppm	.2 ppm
Arsenic	As^{+5}	.090 ppm	0 ppm
Lead	Pb^{+2}	.100 ppm	0 ppm

Waste water can be sustainably treated through a series of small ponds containing rock filtration to remove debris, or plants to remove metals and reduce algae growth. This method is already in use in areas that can support wetland life in Mediterranean countries[5]. In this research a series of tanks will be used as ponds, and water contaminated with a pre-determined amount of heavy metals will be used as waste water. Several tanks of water will be set up with the above listed amount of one particular metal dissolved in each. The aquatic plants will be allowed to grow in the tanks of water for the duration of the project. The heavy metal content of both the water in the tanks and the plants in the water will be measured several times a week throughout the project. The heavy metal content in the water will be tested with Gas chromatography-mass spectrometry (GC-MS). The plants will be dried, ground finely and digested with acids, and then the digestion will be analyzed for heavy metal content. This experiment will test the ability of the plants to remove heavy metals from the contaminated water over time. The plants chosen for this experiment were selected based on several factors. First, the plants must be aquatic in order to grow in wastewater. Next, the plants must be invasive in order to facilitate quick growth in waste water. Lastly and most importantly these plants must be readily available in developing countries. The plants that will be used are: *Nymphaea mexicana* (Mexican Water Lily) *Pistia stratiotes* (Water cabbage), and *Nymphoides peltata* (Yellow Floating-Heart).

Educational Value

I am highly interested in solutions to environmental problems through the use of engineering in developing countries. This project will give me a chance to build on preceding engineering research on waste water treatment and use the concept of sustainable and environmentally sound solutions to a problem. It will also give me valuable experience with solving problems under the limitations of developing countries. Since I plan to work as an environmental engineer in developing countries, this research will be applicable to my life goals.

Significance of Research for Environmental Quality

The disposal of wastewater is a major issue in developing countries. Sewage remains untreated and results in waste water high in bacteria and heavy metals. As this water is released untreated into the general water supply it causes massive algal blooms that remove oxygen from the waterways, killing animal and plant life. The massive heavy metal poisoning causes sickness and death in animals as well as humans, and the diseases present in the water kill the residents of developing countries where little medical care is available. Another concept to note is that most

[3] Garver, S. R., J. K. Farmer, and S. J. Spiegel. "Heavy Metal Concentrations in Municipal Wastewater Treatment Plant Sludge." Environmental Contamination and Toxicology 35 (1985): 38-43.

[4] As listed by the Environmental Protection Agency

[5] Bdour, Ahmed N., Moshrik R. Hamdi, and Zeyad Tarawneh. "Perspectives on Sustainable Wastewater Treatment Technologies and Reuse Options in the Urban Areas of the Mediterranean Region." Desalination 237 (2009): 162-74.

water that flows through local rivers and streams eventually goes out to sea. The pollution in the ocean caused by poor or nonexistent wastewater treatment affects everyone on the planet negatively.

Feasibility

This project requires a specific list of materials: tanks for the contaminated water, aquatic plants for the heavy metal removal, fluorescent lights to allow photosynthesis in the aquatic plants, distilled water, the metals in the concentrations given in the Proposed Research section, the protective equipment required to handle heavy metals, and the equipment needed to test the water for heavy metal content. These materials are largely easy to obtain or are present in labs at Harvey Mudd College. The tanks can easily be bought from most aquatic supply stores. The aquatic plants will be easy to obtain and grow because the parameters of the research require this. The equipment needed to obtain samples of and test the water is available in the labs on Harvey Mudd Campus. Protective equipment needed to handle the water and plants containing heavy metals is also easily purchased. The disposal of the heavy metals will be coordinated by the Safety officer on campus, but may need to be funded by this research. Because of this possibility I have included the heavy metal disposal in my budget. Hopefully some of the cost can be covered by the waste disposal budget at Harvey Mudd College.

I also have sufficient background to complete this experiment because I have a good understanding of the structure and chemical behavior of plants from my studies of Biology in high school and in Bio 52. Since I have taken both Chemistry and Chemistry Lab courses I am familiar with the equipment required to test the water samples. My extensive engineering classes have prepared me for the engineering analysis I will undergo on the results of this research.

Budget

Tanks (to grow plants in): $700
Aquatic Plants: $50
Fluorescent Lights and Mounting Supplies: $60
Safety Equipment: $100
Heavy Metals: $600
Clean-up costs: $3,500
Salary: 10 weeks, 40 hr/week, Harvey Mudd pay scale