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Water Lettuce for Removal of Nitrogen and Phosphate from Sewage

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Abstract : *The concept of using phytoremediation to treat wastewater has received a good recognition. Release of untreated domestic wastewater into the environment has negative influence on the environment. Phytoremediation (using aquatic plants) has good efficiency in removing pollutants in domestic effluents. It is economically beneficial, environment friendly and no energy is required in this treatment process. The main objective of this study was to determine the nutrient (nitrogen and phosphate) removal efficiency of water lettuce from sewage. Treatment was carried out using two plastic troughs of dimension 1m length, 0.3m width and 0.3m depth, one with water lettuce and the other as control unit. Sewage sample was analyzed for nitrate nitrogen, Ammoniacal nitrogen and phosphate. It was observed that water lettuce was capable of removing 83.3% nitrate nitrogen, 84.8% Ammoniacal nitrogen and 81.6% phosphate after 10 days of treatment. After treatment, the sewage water can be used for non-potable purposes.*
Keywords: *Nutrients, Sewage, treatment, Water lettuce.*

I. Introduction

Water is the principle requirement for the existence of life in the world. Water is likely to become a scarce resource in the upcoming decades. Humans are responsible for polluting the source of water due to their negligence. Hence we are responsible for the recycling of water to protect our water bodies from further pollution and overuse. Nutrient removal from the domestic wastewater generated is essential to protect receiving waters from eutrophication[1] and for potential reuse of the treated water. Hence, an attempt is to be made to study the removal of nutrients from domestic wastewater using Water lettuce (free floating aquatic plant). Treatment using Free floating aquatic plants is different from root zone treatment system. The treatment using constructed wetland system is usually based on the design, dimension, the substrate used and plants used. But the treatment using free floating aquatic plants is simple, cost effective, requires low maintenance and requires no energy[2],[3].

It is widely recognized that the following are the normal reasons for inadequate efficiency of the sewage treatment systems existing at present.

- A treatment system such as activated sludge systems is highly sensitive and necessitates good monitoring and efficient process control. In most parts of the country, reasons such as lack of awareness, non-availability of trained staff, etc., make it difficult to operate a sophisticated wastewater treatment technology i.e., the complexity of technology.
- Most of these treatment systems are highly mechanized and need good preventive maintenance. With good maintenance practices being scarce, the system with high maintenance requirement remains highly vulnerable.
- Cost of treatment of most of such systems is very high due to high power consumption, which prevents many from operating it continuously.
- Most of these systems, particularly the ASP, are highly dependent on uninterrupted power supply for its effective operation. With frequent power failures in most parts of the country, the reliability of such systems is low.

The need for a technology which is simple in operation, low maintenance, low cost in operation and self-sustaining are quite evident. The natural wastewater treatment options such as treatment using aquatic plants are becoming quite attractive in this view.

II. Treatment Using Aquatic Plants

2.1 Phytoremediation

Phytoremediation (Phyto means Plant) is a generic term for the group of technologies that use plants for remediating soils, sludge, sediments and water contaminated with organic and inorganic contaminants. Phytoremediation can be defined as “the efficient use of plants to remove, detoxify or immobilize environmental contaminants in a growth matrix (soil, water or sediments) through the natural biological, physical or chemical activities and processes of the plants”. Plants are unique organisms equipped with remarkable metabolic and absorption capabilities, as well as transport system that can take up nutrients or contaminants selectively from the growth matrix, soil or water. Phytoremediation involves growing plants in a contaminated matrix, for a required growth period, to remove contaminants from the matrix, or facilitate immobilization or degradation (detoxification) of the pollutant. The plants can be subsequently harvested, processed and disposed.

Phytoremediation can be used to clean up metals, pesticides, solvents, explosives, crude oil, polyaromatic hydrocarbons, and landfill leachates, It can also be used for river basin management through the hydraulic control of contaminants. There are several ways in which plants are used to clean up, or remediate contaminated sites. The uptake of contaminants in plants occurs primarily through the root system, in which the principle mechanisms for preventing contaminant toxicity are found. The root system provides an enormous surface area that absorbs and accumulates the water and nutrients essential for growth, as well as other non-essential contaminants.

2.2 Treatment using aquatic plants

Aquatic plant system has been accounted as one of the processes for wastewater recovery and recycling[4]. The main purposes of using this system have focused on waste stabilization and nutrient removal. The principal removal mechanisms are physical sedimentation and bacterial metabolic activity as in the conventional activated sludge and trickling filter. Plant assimilation of nutrient and its subsequent harvesting are another mechanism for pollutant removal[5]. Low cost and easy maintenance make the aquatic plant system attractive to use. Thus, constructed ponds with aquatic plants are increasingly applied as a viable treatment for municipal wastewater. However, there are some constraints with using aquatic plants such as the requirements or large area of land, the reliability for pathogen destruction, and the types and end-uses of aquatic plants.

Water hyacinth (Eichhornia crassipes) treatment systems are generally known in tropical areas. The systems with water hyacinth can operate at higher loading rates. Their end-use products can be utilized for mulch and organic fertilizer. Dry water hyacinth petioles can be woven into baskets and purse. Beside that, there are many potential aquatic plants that can be used for wastewater treatment but they have not been investigated or there is a lack of data collections. In this study, the efficiencies of water lettuce is to be investigated.

III. Materials And Methods

Water lettuce, a free floating aquatic plant was collected from a nearby pond manually and it is washed thoroughly and then used for experimental purpose.

3.1 Experimental set up

The experimental setup consists of two plastic troughs each with a dimension of 1m length, 0.3m width and 0.3m depth. Water lettuce is planted in one trough and the other trough is kept as control unit. Sewage samples are collected in plastic cans which are washed thoroughly with distilled water. The experiment was carried out for 10days. Water sample from treatment unit and control unit are analyzed once in two days for their nitrogen and phosphate concentration.

Two sets of trough consists of

i. Set up 1- Sewage (40 lit) + water lettuce

ii. Set up 2 – control unit (without plant)

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IV. Result And Discussions

Nitrogen is present in the form of Nitrite, Nitrate and Free ammonia in sewage. Since the concentration of Nitrite Nitrogen was very low, it was not analyzed after treatment. Nitrate nitrogen, Ammoniacal nitrogen and Phosphate were analyzed before and after treatment and the nutrient removal efficiency of water lettuce was found.

Nitrate Nitrogen:

The concentration of Nitrate nitrogen present in sewage before and after treatment is shown in table 4.1 and removal efficiency of water lettuce is shown in table 4.2.

Table 4.1 Concentration Of Nitrate before and after treatment

Parameter	Concentration before treatment	Duration of Analysis	Concentration after treatment	
Nitrate Nitrogen (as NO3-N) mg/l	25.7		Set up 1	Set up 2
		2^{nd} day	23.2	25
		4^{th} day	19.1	24.7
		6^{th} day	15.3	24.1
		8^{th} day	10.2	24
		10^{th} day	4.3	23.8

Table 4.2 Nitrate Removal efficiency of water lettuce

Parameter	Duration of analysis	Removal efficiency(%)	
Nitrate Nitrogen		Set up 1	Set up 2
	2nd day	10.7	2.7
	4th day	25.6	3.9
	6th day	40.5	6.2
	8th day	60.3	6.6
	10th day	83.3	7.4

It was observed that water lettuce is capable of removing 83% of nitrate nitrogen at the end of 10th day. Nitrate concentration gradually decreases day by day. This is because of the intake of nutrients by plants for its growth. Fig 4.1 shows the graphical representation of removal efficiencies(%).

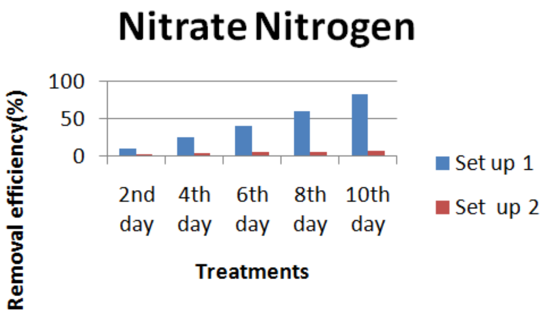

Fig. 4.1 Graphical representation of nitrate removal efficiency of water lettuce

Ammoniacal Nitrogen:

The concentration of Ammoniacal nitrogen present in sewage before and after treatment is shown in table 4.3 and removal efficiency of water lettuce is shown in table 4.4.

Table 4.3 Concentration Of Ammoniacal Nitrogen before and after treatment

Parameter	Concentration before treatment	Duration of Analysis	Concentration after treatment	
Ammoniacal Nitrogen (as NH3-N) mg/l	38.3		Set up 1	Set up 2
		2nd day	34.2	37.1
		4th day	28.8	35.8
		6th day	20.3	35
		8th day	14.1	34.3
		10th day	5.8	33.1

Table 4.4 Ammoniacal Nitrogen Removal efficiency of water lettuce

Parameter	Duration of analysis	Removal efficiency(%)	
Ammoniacal Nitrogen		Set up 1	Set up 2
	2nd day	10.7	3.1
	4th day	24.8	6.5
	6th day	47	8.6
	8th day	63.2	10.4
	10th day	84.8	13.6

Water lettuce removed 84.8% of Ammoniacal nitrogen at the end of 10th day. Graphical representation of removal of Ammoniacal nitrogen in various set up is shown in fig 4.2.

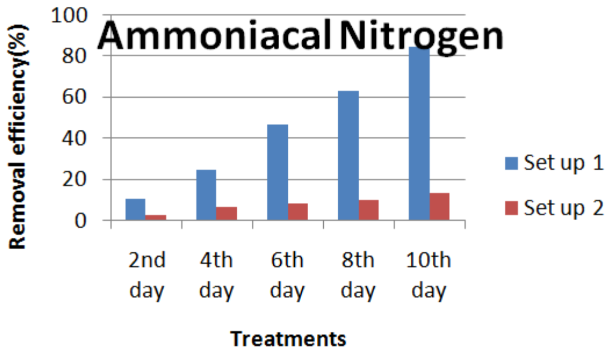

Fig. 4.2 Graphical representation of ammonia removal efficiency of water lettuce

Phosphorous:

The concentration of Phosphate present in sewage before and after treatment is shown in table 4.3 and removal efficiency of water lettuce is shown in table 4.4.

Table 4.5 Concentration Of Phosphorous before and after treatment

Parameter	Concentration before treatment	Duration of Analysis	Concentration after treatment	
			Set up 1	Set up 2
Phosphorous	23.4	2nd day	20.1	23.1
		4th day	16.4	22.8
		6th day	12.3	22
		8th day	9.2	21.4
		10th day	4.3	21.6

Table 4.4 Phosphorous Removal efficiency of water lettuce

Parameter	Duration of analysis	Removal efficiency(%)	
		Set up 1	Set up 2
Phosphorous	2nd day	14	1.3
	4th day	30	2.6
	6th day	47.4	6
	8th day	60.3	8.6
	10th day	81.6	7.7

Water lettuce removed 81.6% of Phosphate at the end of 10th day. Graphical representation of removal of Phosphate in various set up is shown in fig 4.3.

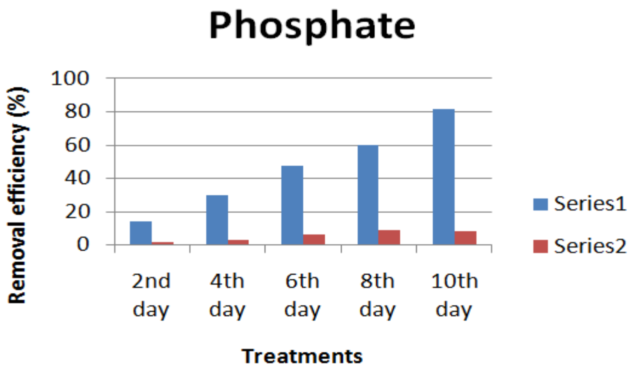

Fig. 4.3 Graphical representation of Phosphate removal efficiency of water lettuce

V. Conclusion

It was observed that water lettuce performs good in removing nutrients from sewage. Water lettuce has an efficiency of removing 83% nitrate nitrogen, 84.8% ammoniacal nitrogen and 81.6% Phosphate from sewage. After treatment using water lettuce, sewage can be either disposed of into the water bodies so that the quality of water body will not be affected or it can be reused for gardening or flushing purposes. It is evident that the treatment using water lettuce is very simple and it is eco friendly.

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