A STUDY TO DETERMINE THE EFFICIENCY OF *LEMNA MINOR* AND *PISTIA STRATIOTES* IN DETERGENT WATER TREATMENT

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Abstract

The present study was conducted to evaluate the phytoremediation potential and pollutant removal efficiency of *Lemna minor* and *Pistia stratiotes* to treat detergent water. The study was carried for 30 days and at an interval of 5 days, various physicochemical parameters like pH, Conductivity, Total dissolved Solids, Dissolved oxygen, Nitrate, Phosphate, Potassium and Sodium levels were analysed. pH levels were brought to near neutral by both plant species. *Lemna minor* managed to reduce the concentration of above-mentioned parameters except Phosphate levels which was increased by it and also negatively affected the Dissolved oxygen values by decreasing it. *Pistia stratiotes* showed a better reducing efficiency by decreasing Conductivity and Total Dissolved Solids by 23.07%, Phosphate by 27.27%, Nitrate by 78.31%, Potassium by 15.28%, Sodium by 12.45% and increased Dissolved oxygen level by 3.3%. All parameters examined were within the permissible limits of WHO and BIS standards. In this experiment *Pistia stratiotes* was found to be more efficient in pollutant removal and depicted better tolerance towards detergent water. Both the plant species showed optimum growth. Cross- sections of plant parts enabled in understanding waste uptake and trapping by plants during root to shoot transportation.

Keywords: Detergent water, wastewater treatment, *lemna*, *pistia* and phytoremediation.

I. Introduction

Human activities like Industrialization, dumping of waste etc. directly into the water bodies has led to contamination of lakes, rivers, oceans, groundwater and aquifers. Water pollution, due to release of inadequately treated water can not only lead to degradation of aquatic ecosystem but can also cause worldwide health problems and deaths (water borne diseases). One of the main sources of the water pollution is from municipal wastewater. Usually, municipal wastewater comes from residential area, restaurant, and cafeteria, industrial or agricultural effluent. This municipal waste consists of organic and inorganic waste, which includes food scraps, waste oils and detergent (Wang et al.,2001). Usually, municipal wastewater will undergo pretreatment before it is discharged into the river. A conventional sewage treatment involves physical, chemical and biological process. Physical process includes sedimentation and filtration, chemical process mostly includes ozonation and neutralization. In biological treatment process, micro-organisms such as bacteria are used to biochemically decompose the wastewater and stabilize the end product (Chandekar and Godboley, 2017). Conventional sewage treatment process is very complex, costly and still contribute to pollution because it uses chemical reagent to treat the wastewater.

Natural treatment systems came back into consideration mostly as an attempt to find a more cost-effective means of achieving the mandated treatment levels than was available with the existing mechanical or chemical processes. Natural treatment systems are not disposal practices, nor are they random applications of waste and wastewater in various habitats. Natural treatment systems are engineered facilities which utilize the capabilities of plants, soils, and the associated microbial populations to degrade and immobilize wastewater

contaminants. The two main categories of natural treatment system, are land treatment and aquatic treatment systems (Hastie, 1992). In which Aquatic treatment involves passing wastewater through either wetlands or other aquatic plant ecosystems, whether natural or man-made. Removal of contaminants takes place by plant uptake, microbial degradation, filtration, chemical precipitation and sedimentation. However, it is important in determining the appropriate macrophytes species that can survive in the wastewater environment, because only suitable macrophytes can treat a high concentration of pollutant in the waste water (Xia et al.,1994).

Floating aquatic macrophytes system are much better to use compared to the emergent macrophytes treatment system in term of nutrient uptake efficiency, especially macrophytes that has a large roots system. Several studies documented that floating macrophytes such as *Pistia Stratiotes* (water lettuce) and *Eichhornia crassipes* (water hyacinth) have the capability to remove a large amount of pollutant, capability to survive at any wastewater environment and   also has the highest growth rate (Alade et al., 2009 and Gunnarsson et al.,2007). Utilization of aquatic macrophytes for wastewater treatment has been reported as an economical device. For the treatment of wastewater several aquatic macrophytes growing naturally in polluted water have recently been used for the removal of pollutants as they consume them as nutrients (Reddy and De Busk, 1985).

Macrophytes are the potent phytoremediators and the macrophytes phytoremediation mechanism consists of several processes such as phytoextraction, rhizofiltration, phytostabilization, phytovolatilization and phytotransformation or phytodegradation in which each of the process have different role in the accumulation and remediation of the metals (Rai, 2008). Hyper-accumulating plants are able to accumulate, translocate and concentrate high amount of hazardous elements in the harvestable part (Rai, 2008 and Rahman, 2011).

The phytoremediation techniques are economically feasible require low maintance and operations cost. It is a better alternative for developing countries as it consumes near to no energy in comparison to other conventional treatment systems.

The goal of the present study was to evaluate the phytoremediation potential and pollutant removal efficiency of *Lemna minor* and *Pistia stratiotes* to treat detergent water. It was also aimed to check whether the detergent effects the growth and anatomical structures of the plant.

II. Materials and Methods

The study was conducted in the department of zoology, CMS College Kottayam, Kerala, India.

Collection of Materials

- The plants *Lemna minor* (Duckweed) and *Pistia stratiotes* (Water lettuce) belonging to the family Lemnaceae and Araceae respectively, were collected from a pond in Kumarakam area of Kottayam district, Kerala. These floaters were brought to the laboratory, washed, cleaned and planted in stock plastic crates containing clean water. They were allowed to acclimatize with the new environmental condition for one week.
- Plastic crates of 7-liter capacity and detergent powder (surf excel) were purchased from Kottayam market.

Experimental setup

The whole treatment setup was set near a window, so that the plants get proper access to sunlight. A 7-liter plastic crate was taken to which, 1-gram detergent powder dissolved in 100 ml water was added. Followed by

this the crate was filled with water upto 6 liters, after 1 hour thoroughly washed plant species were taken from stock crates and transferred to the treatment crates containing detergent water. Three replicates of each experimental set were kept in the laboratory. Prior to the introduction of plants initial pH, conductivity, TDS, Dissolved oxygen, Phosphate, Nitrate, Potassium and Sodium levels were examined. In order to explain the efficiency of plants in water purification the study was conducted for 30 days and at an interval of five days the treated water samples were analyzed**.**

Examination of water quality

The physicochemical characteristics of initial untreated detergent water and plant treated samples were examined using EUTECH 650 Multiparameter water analyser. The parameters analysed include pH, Conductivity, Total dissolved solids (TDS), Dissolved Oxygen (DO). Nitrate and Phosphate contents were examined by following standard APHA procedures and the values obtained were measured using UV-VIS Spectrophotometer 117. Potassium and sodium levels at each interval were measured using Flame photometer 130.

Anatomical analysis of plant parts

Cross-sections of different plant parts were taken in order to study the effect of detergent water on plant tissues. Photographs of plant cross-sections were taken using stereo zoom microscope – Labomedluxeo 4D and the images captured were processed using pixelpro software.

III. Result and discussion

Data obtained during the present laboratory Study are shown in Table.1 and figure 1-8.

Table.1 showing the Mean± standard deviation values of initial and treated detergent water using *Lemna minor* and *Pistia stratiotes*

Parameters	Mean of Initial Untreated detergent water	Mean ±SD of Treated water			
		Lemna minor	Reduction %	*Pistia stratiotes*	Reduction %
pH	6.56	6.84±0.20	-	6.62±0.16	-
Conductivity (µS/cm)	578.8	484.92±71.53	16.2	445.22±94.86	23.07
TDS (ppm)	289.4	242.62±35.76	16.16	222.63±47.43	23.07
Dissolved oxygen(mg/l)	3	2.35±0.44	-	3.10±1.11	-
Phosphate (mg/l)	0.0022	0.0027±0.0026	-	0.0016±0.0015	27.27
Nitrate (mg/l)	5.21	1.14±1.80	78.11	1.13±1.84	78.31
Potassium (mg/l)	14.98	13.88±0.81	7.3	12.69±1.25	15.28
Sodium (mg/l)	100.88	92.60±5.49	8.2	88.32±10.61	12.45

pH of the detergent water was 6.56 (Table.1), which is slightly acidic in nature. This during the treatment process was slowly raised by both the plant species and by end of the experiment that is before the 30th day, *Lemna minor* was able to bring the pH to neutral level that is at 7 (fig.1). Similarly, *Pistia stratiotes* also

managed to bring pH to near neutral level and as per BIS standards these values were within the desirable limits.
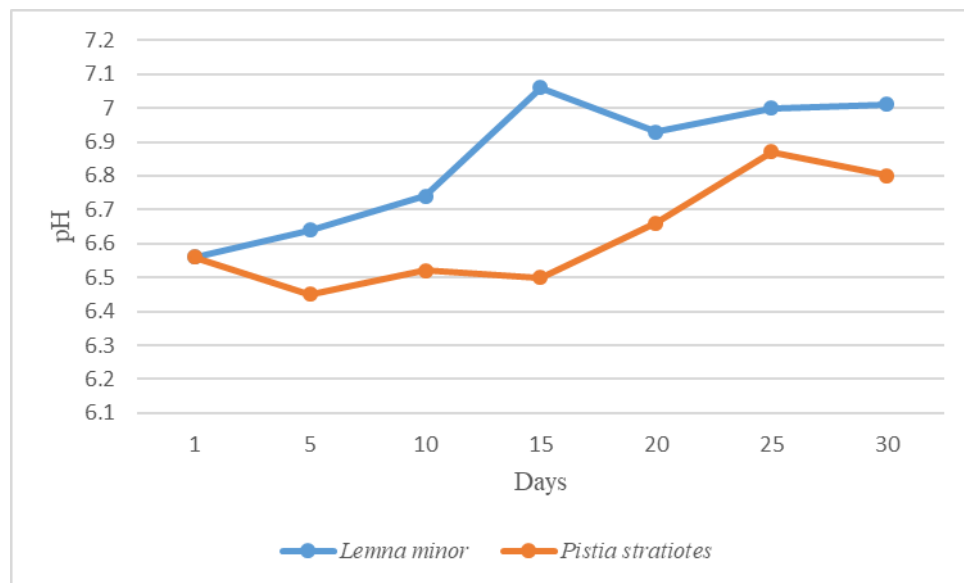

figure 1. graph showing mean variations in the pH values of the treated water.

Conductivity is the Concentration of ions in water, the untreated detergent water had a Conductivity of 578.8 µS/cm (Table.1). *Lemna minor* showed 16.2% removal efficiency of ions while *Pistia stratiotes* showed 23.07%. The inorganic ion concentrations were decreasing with increasing number of days and in this experiment *Pistia stratiotes* showed better ionic removal efficiency (fig. 2).
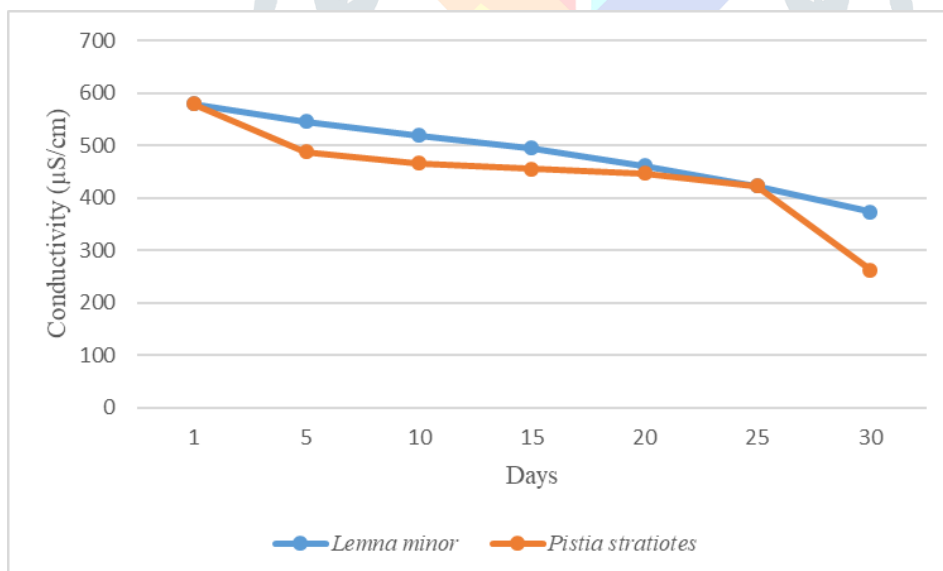
figure 2. graph showing mean variations in the conductivity (µS/cm) values of the treated water.

Figure 3. Shows the Total dissolved solids (TDS) of the water, TDS may increase or decrease based on the mineral elements, charged macromolecules and other ionic compounds present in the water. In this study the mean initial TDS value of the detergent water was 289.4 ppm (Table.1), which was decreased 16.16% by *Lemna minor* and 23.07% by *Pistia stratiotes*. TDS removal efficiency was more seen in *Pistia stratiotes* in comparison to *Lemna minor*.
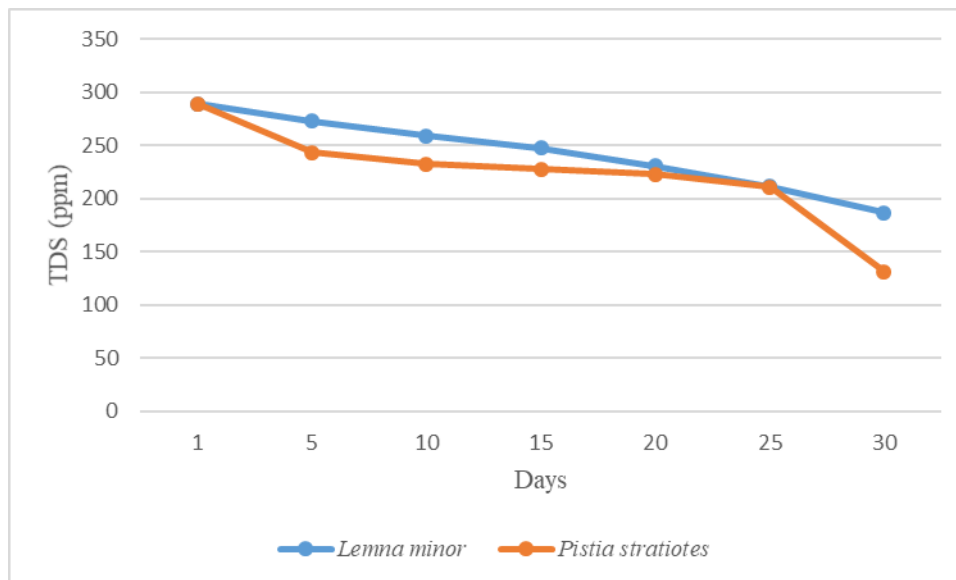
figure 3. graph showing mean variations in the Total dissolved solids (TDS) values of the treated water.

Dissolved oxygen (DO) level of detergent water initially was 3mg/l (Table.1) and after starting the experiment, for few days the DO kept on decreasing in the treatment system but after 10 days of treatment the values started to increase (fig.4). Appropriate DO content is important for proper functioning of microorganisms and other biota in wastewater treatment system. During the experimental time period *Lemna minor* decreased the DO level 21.6% while Pistia *stratiotes* increased its level at an average of 3.3%. In this case *Pistia stratiotes* was able to slightly raise DO levels.
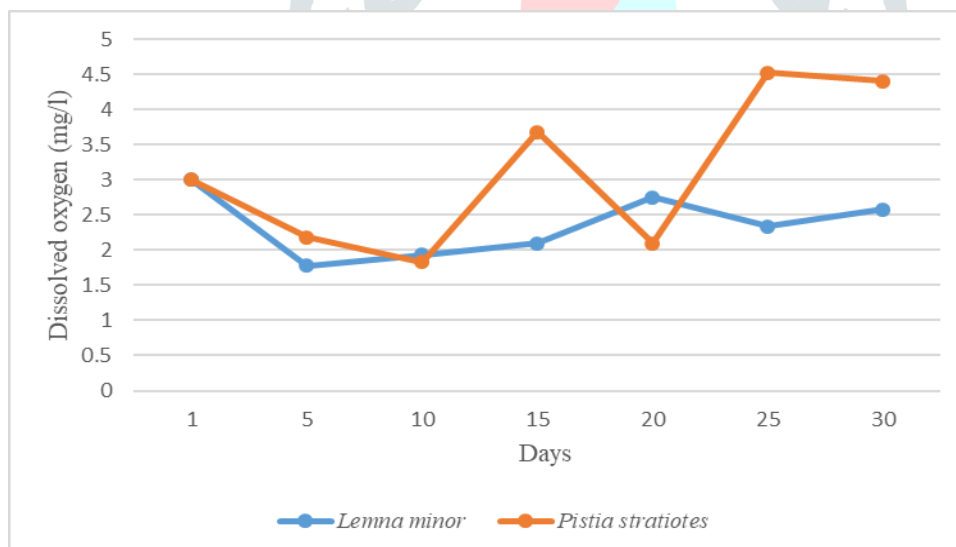

figure 4. graph showing mean variations in the Dissolved oxygen (mg/l) values of the treated water.

The initial Mean Nitrate levels of detergent water was 5.21 (Table.1), which was drastically reduced by both plant species to high extent (fig.5). *Lemna minor* showed a removal efficiency of 78.11% while *Pistia stratiotes* showed 78.31%. Both species were able to reduce nitrate levels to a very good extent, WHO ,1993 has fixed the value of nitrate in drinking water to be 50 mg/l and BIS has set a desirable limit of nitrate in drinking water to be 45 mg/l. In the present study nitrate values were found to be less than the standard permissible limits of BIS, 2012 and WHO.
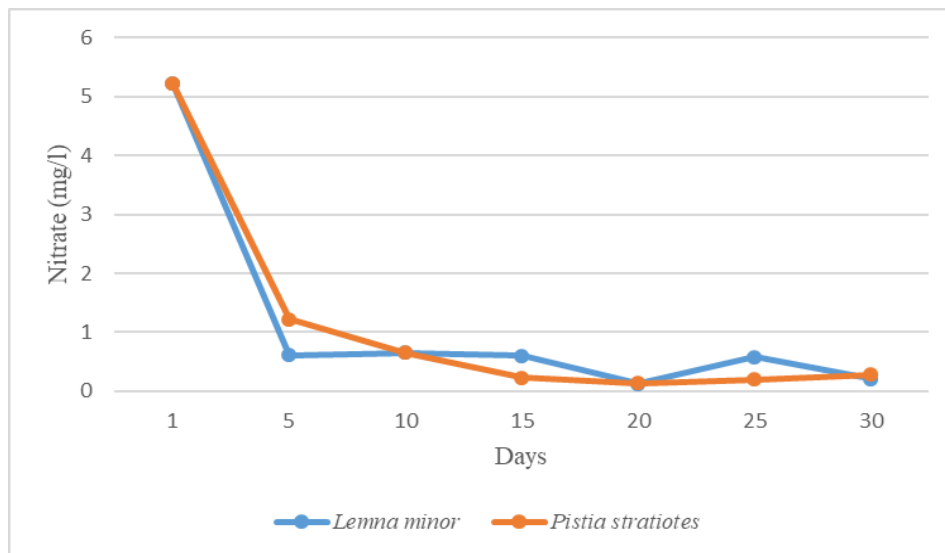
figure 5. graph showing mean variations in the Nitrate (mg/l) values of the treated water.

Initial Mean Phosphate levels of detergent water was 0.0022 mg/l (Table.1), which was increased initially by both species at the start of the treatment process but later on its level was decreased by *Pistia stratiotes* with increasing number of days (fig.6). *Lemna minor* increased the phosphate level at an average of 22.7%, While *Pistia stratiotes* showed a reduction of 27.27%. High phosphate level can accelerate dense growth of algae and plants in the water. WHO has fixed phosphates permissible limit to be 0.1 mg/l and in this experiment phosphate values examined at each interval were below the permissible limit.
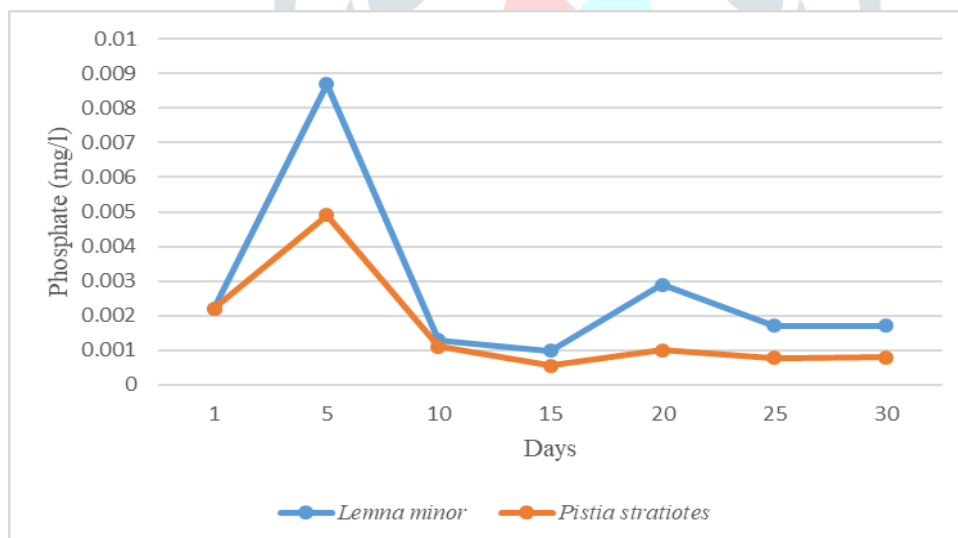

figure 6. graph showing mean variations in the Phosphate (mg/l) values of the treated water.

 The initial Mean Potassium and Sodium values of detergent water were 14.98 and 100.88 mg/l (Table.1), which were decreased by both plant species. Potassium removal efficiency of *Lemna minor* and *Pistia stratiotes* were 7.3% and 15.28% respectively (fig.7), while Sodium removal efficiency of *Lemna minor* and *Pistia stratiotes* were 8.2% and 12.45% respectively (fig. 8). In both the cases *Pistia stratiotes* performed better in reducing the level of Potassium and Sodium from the treatment system.
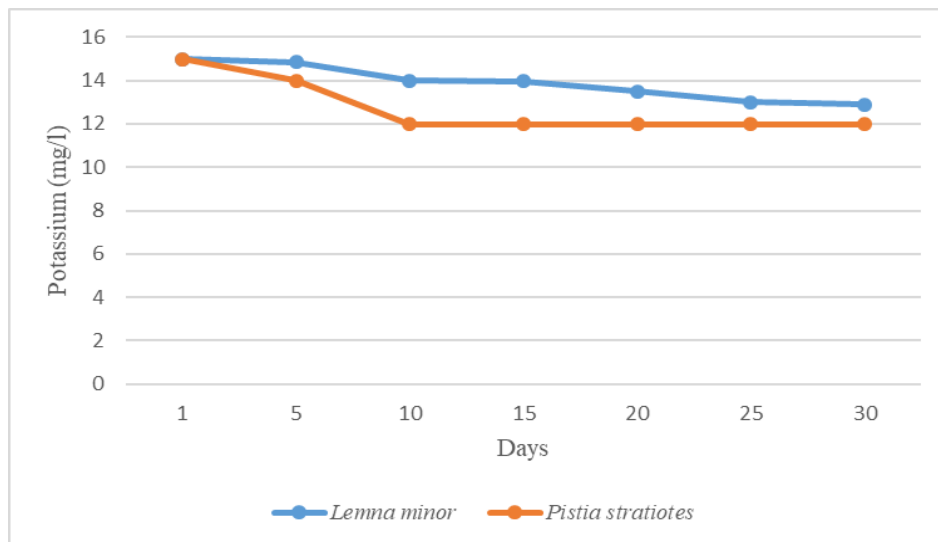
figure 7. graph showing mean variations in the Potassium (mg/l) values of the treated water.
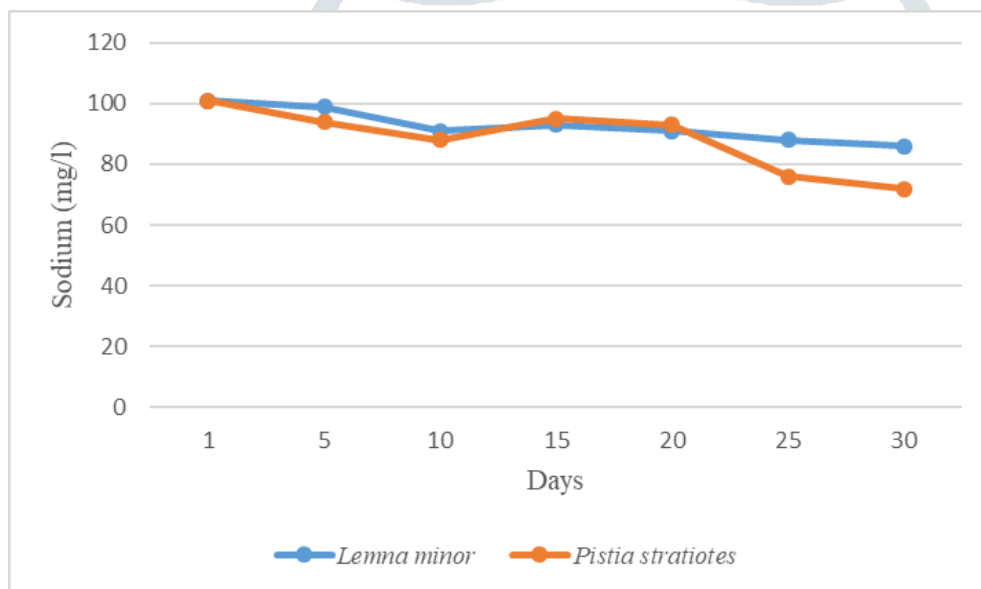

figure 8. graph showing mean variations in the Sodium (mg/l) values of the treated water.

Anatomical analysis of plant cross-sections

Cross-sections of various plant parts were taken like of root, stem, leaf and stolon. Examination of *Lemna minor* cross-sections did not showed any trapped pollutants but examination of *Pistia stratiotes* root cross-section showed trapped particulates in their parenchyma cells, which also function as storage cells (fig.9). It was clear by examination of all cross-sections that there was no alteration in the cells and tissues of the plants, which means both the plants were tolerant to detergent water and can be frequently used in large scale biological wastewater treatment systems.
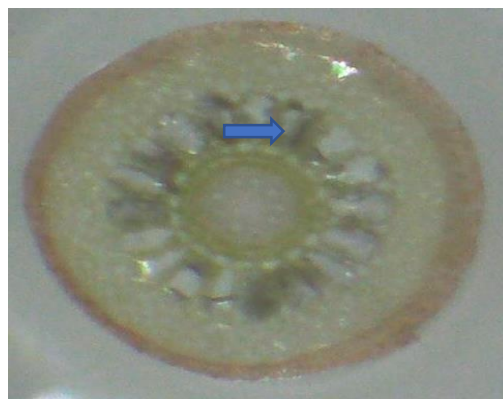
figure 9. Showing root cross-section of *Pistia stratiotes*.

IV. Conclusion

From the results of this study it could be concluded that both plant species have efficiency in pollutant removal from wastewater. These free floaters were uptaking pollutants through their well-developed roots and transporting it to different plant parts for various purposes. These features of the plant helped in decreasing turbidity of the wastewater and helped in promoting phytoremediation activities of the plant. *Pistia stratiotes* showed a better reducing efficiency by decreasing Conductivity and Total Dissolved Solids by 23.07%, Phosphate by 27.27%, Nitrate by 78.31%, Potassium by 15.28%, Sodium by 12.45% and increased Dissolved oxygen content by 3.3%. *Lemna minor* also showed reducing efficiency but was increasing the phosphate level and decreasing the dissolved oxygen level. Both plants used in the experiment showed good biomass growth in the wastewater. Cross-sections of *Pistia stratiotes* root part showed trapped pollutants in their parenchyma cells, without effecting the anatomy of the plant tissues. All parameters analysed were within the permissible limits and was found safe to reuse for agricultural purpose, washing vehicles and discharging into the aquatic ecosystem. Since it is a natural treatment process, therefore it is cost effective, least energy consuming, eco-friendly and can be most promising alternative of wastewater treatment system for developing countries.

V. Acknowledgement

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