RESEARCH ARTICLE

EVALUATION OF TREATMENT OF DOMESTIC WASTEWATER USING EICCHORNIA CRASSIPES AND PISTA STRATIOTES BY PHYTOTECHNOLOGIES

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ABSTRACT

Water shortage is now one of the major issues of the global world. Water scarcity is increasing day by day. The availability of water is decreasing. The need of hour is to treat the wastewater for dealing water crisis and using it for various purposes. This study involves the treatment of domestic wastewater using phytoremediation technique. The two aquatic plants named Eichhornia crassipes (Water hyacinth) and Pistia stratiotes (Water lettuce) were used. The parameters investigated in this research were pH, TDS, Turbidity, EC, TSS and temperature. These parameters were checked at various retention times after every three days interval. The objective of this study was to get higher efficiencies of these two aquatic plants in improving the parameters involved in the research. The adequacy of the treatment parameters was also validated using statistical analysis. It was established by the results at the end of the experiment that maximum efficiencies were achieved by this phytoremediation technique. This concluded that these two aquatic plants treated the wastewater to such an extent that it can be safely disposed in the drains.

KEYWORDS

Wastewater, biological treatment, Eichhornia crassipes, Pistia stratiotes.

1. INTRODUCTION

Landfilling is one of the human activities that has completely changed the natural ecosystem's sustainability destiny (Abbas *et al.*, 2019). Sanitary waste disposal is widely used for the global municipal management of solid waste (Abinaya *et al.*, 2018). Leachate is hazardous wastewater that is generated mainly by waste collection, transfer and disposal, with high organic ammonia, pH (Adler *et al.*, 2003). Accurate management and treatment of the waste disposal leachate is therefore necessary to avoid the adverse impact that contaminants can have before the final disposal in the environment (Ajayi, T. O *et al.*, 2012).

The concept of using plant remediation is extremely esthetic and can be used to extract pollutants from the large contaminated environment, where other chemical and physical remediation techniques are not available and expensive (Akansha *et al.*, 2020). The plant used in phytoremediation eliminates pollutants without affecting the quality of soil products and, thereby, retains soil fertility and utility (Barac *et al.*, 2004). Strong, economic and sustainable technology is the most affordable phytoremediation to date. It is solar-powered, environmentally friendly and locally cleaned (Borker *et al.*, 2013).

The selection of plant species for plant remediation is an important issue, as they must survive and deal with their variability in a toxic environment of effluents. Intrusive plants in phytotechnology are extremely useful for reducing pollutants (Chen *et al.* 2014).

Water hyacinth (*E. crassipes*) belongs to the Pontederiaceae family. It is classified as one of the most raging weeds in the world (de Alkimi *et al.* 2020). *Eichhornia crassipes* have been confirmed to be the best particle

contamination phytoremediator (Dhanwal *et al.* 2017). Water hyacinth was identified as the best candidate for phytoremediation of pulp and paper mill effluents with specific organic EC (electric conductivity), TDS, COD, BOD, TKN, as compared to other aquatic plants.

Higher EC-containing levels of killing strength allow the survival of water lettuce (Ebel *et al.*, 2007). The purpose of this study was therefore to evaluate *E. crassipes* and *P. stratiotes* performance for phytoremediation of waste fill leachate.

To encounter these problems study will focus on: To treat domestic wastewater using aquatic plants and to check the removal efficiency of aquatic plants for different parameters.

2. MATERIAL AND METHODS

2.1 Study area

Faisalabad once in the past known as Lyallpur, is the third-most-stuck city in Pakistan, and the second-most prominent in the eastern area of Punjab. All things considered one of the essential engineered metropolitan areas inside British India, it has since a long time past outlined into a cosmopolitan city. Faisalabad was changed into city district status; a devolution declared by the 2001 neighborhood government goal (LGO). The rigid space of Faisalabad District is 5,856 km² (2,261 sq mi) while the region obliged by the Faisalabad Development Authority (FDA) is 1,280 km² (490 sq mi). Faisalabad has shaped to change into a basic mechanical and dispersing focus due to its focal district in the region and interfacing streets, rails, and air transportation. It has been recommended as the "Manchester of Pakistan". As of 2013, the GDP (PPP) of Faisalabad was

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assessed as \$43 billion and projected to move to \$87 billion out of 2025 at a progression speed of 5.7%. Faisalabad offers more than 20% to Punjab's GDP and has a common yearly GDP (clear) of \$20.5 billion. Developing and industry remain its image name.

Wastewater is depleted out of Faisalabad through a development of channels that at last appear at the Ravi River in the east and the Chenab River in the west. The stream is about 5.3 m³/s from the eastern side of the city and 4.1 m³/s from the western side. The downstream effects of the waste got by these two streams is reflected in the way that the Chenab is dirtied such a lot of that split up oxygen (DO) is completely drained in 12% of the length of the stream and the biochemical oxygen premium (BOD) downstream of Faisalabad is 4.2 mg/l. The Ravi is Pakistan's most contaminated stream, getting 47% of the normal and mechanical contamination load conveyed into the entirety of the surges of Pakistan.² The waste streams from Faisalabad have thoughts for occupations since they go through agrarian land. A review of 60 metropolitan organizations across Pakistan with an overall public of somewhere near 100,000 tracked down that an ordinary space of 32,500 ha was being submerged with wastewater by in excess of 19,250 families. The use of wastewater had in all cases began after sewerage frameworks were made, which in certain metropolitan organizations was fundamentally as precisely on time as 1925, yet according to different viewpoints during the 1970s and 1980s (Ensink et al. 2004a). Pakistan isn't the only one in this marvel. In India, for instance, a typical 73,000 ha are inundated with wastewater.

2.2 Plants

2.2.1 Water hyacinth

Eichhornia crassipes, generally known as normal water hyacinth, is a sea-going plant local to the Amazon bowl and is frequently an exceptionally risky intrusive animal category outside its local reach. Water hyacinth is accounted for its proficiency to eliminate around 60–80% nitrogen and about 69% of potassium from water. The foundations of water hyacinth were found to eliminate particulate matter and nitrogen in a characteristic shallow eutrophicated wetland. The plant can likewise screen substantial metals and different poisons from debased water. The underlying foundations of *Eichhornia crassipes* normally retain poisons, including lead, mercury, and strontium-90, just as some natural mixtures accepted to be cancer-causing, in fixations multiple times that in the encompassing water. Water hyacinths can be developed for wastewater treatment (particularly dairy wastewater).

Figure 1: Water hyacinth

2.2.2 Water lettuce

Pistia is a variety of sea-going plants in the arum family, Araceae. The single species it contains, *Pistia stratiotes*, is regularly called water cabbage, water lettuce, Nile cabbage, or shellflower. Its local dissemination is unsure however presumably pantropical; it was first found from the Nile close to Lake Victoria in Africa. It is currently present, either normally or through human presentation, in virtually all tropical and subtropical new streams and is viewed as an intrusive species just as a mosquito rearing environment. The variety name is gotten from the Greek word *πίστις* (*pistes*), signifying "water," and alludes to the amphibian idea of the plants. Water lettuce is frequently utilized in tropical aquariums to give cover to sear and little fish. It is additionally useful as it outcompetes green growth for supplements in the water, subsequently forestalling gigantic algal sprouts.

Figure 2: Water lettuce

2.3 Parameters

Table 1: The parameters used in the analysis		
Sr. No.	Parameters	Units
1	pH	Ratio
2	TDS	mg/L
3	Turbidity	mg/L
4	TSS	mg/L
5	EC	μS
6	Temperature	°C

2.4 Collection of samples

Figure 3: Sample collection

Sample of wastewater using in this study is domestic wastewater which is collected from the small drain of Chak no.208, Faisalabad. Wastewater samples were typically being collected either by directly filling the sample container or by using an automatic sampler or other device. The samples were collected manually using a jug in plastic cans as shown in figure. There are various methods of collecting samples either collecting whole sample at the same time or collecting constant samples at varying time but in this study the samples are collected without varying time proportion and just after taking samples, initial readings of the parameters are taken on the spot.

2.5 Experimental setup

The setup of experiment was set using plastic containers. The containers were filled with wastewater and the aquatic plants, water lettuce and water hyacinth, are added to the wastewater. The number of containers used were twelve because four treatments are carried out in the experiment and each treatment is replicated three times.

Figure 4: Experimental lab setup

2.6 Treatments and methodology

After collecting the samples, the setup of experiment was set using plastic containers. The containers were filled with wastewater and the aquatic plants, water lettuce and water hyacinth, were added to the wastewater. The number of containers used were twelve because four treatments were carried out in the experiment and each treatment was replicated three times. The first treatment (T_0) was control treatment without adding any plant in the sample. In the second treatment (T_1), water lettuce (*Pistia stratiotes*) were added to the three containers of the wastewater samples, third treatment (T_2) was with water hyacinth (*Eichhornia crassipes*) and in fourth treatment (T_3), mixture of both these plants were added to the three wastewater containers as given in table 2 below.

Table 2: Treatments detail

Sr. no	Treatments	Details
1	T ₀	Control
2	T ₁	Domestic Wastewater + Water Lettuce
3	T ₂	Domestic wastewater + water hyacinth
4	T ₃	Domestic wastewater + water lettuce + water hyacinth

The retention time of the analysis was 3 days so the readings of the parameters were taken after every three-day interval (0 day, 3 days, 6 days, 9 days, and 12 day). Measuring parameters were pH, TDS, TSS, Turbidity, EC and temperature.

2.6.1 pH and temperature measurement

The pH and temperature of the water were estimated by the pH meter. The pH meter has two tests one for pH and the second for temperature. These tests were simply dunked in the example and note the readings of the boundaries. The pH scale goes from 0 to 14. As a general rule, water with a pH < 7 is considered acidic and with a pH > 7 is viewed as fundamental.

The typical reach for pH in surface water frameworks is 6.5 to 8.5 and for groundwater frameworks 6 to 8.5. pH was not really set in stone worth dependent on a characterized scale, like temperature. This implies that the pH of water is certainly not an actual boundary that can be estimated as a fixation or in an amount. All things being equal, it is a figure somewhere in the range of 0 and 14 characterizing how acidic or essential a waterway was along a logarithmic scale. The lower the number, the more acidic the water is. The higher the number, the more essential it is. A pH of 7 was viewed as nonpartisan.

2.6.2 TDS and EC estimation

TDS and EC of water were estimated by the TDS meter which has just one test. Turn on the meter, placing the test in the example and afterwards take the readings of the two boundaries utilizing the mode button which can move the method of the boundary from TDS to EC. By and large, the absolute broken up solids focus was the amount of the cations (emphatically charged) and anions (contrarily charged) particles in the water. Hence, the complete broke down solids test gives a subjective proportion of the number of disintegrated particles however doesn't disclose to us the idea of particle connections. What's more, the test doesn't give us knowledge of the particular water quality issues, like Elevated Hardness, Salty Taste, or Corrosiveness. Hence, the complete disintegrated solids test is utilized as a marker test to decide the overall nature of the water.

2.6.3 Turbidity estimation

Turbidity was estimated utilizing the water quality checker instrument. The test was dunked in the example, set the method of the instrument to turbidity since it can likewise gauge different boundaries like conductivity and DO. In the wake of setting the mode to turbidity, simply note the readings when it's worth get steady. Turbidity was the darkness or foggy of a liquid brought about by huge quantities of individual particles that were by and large undetectable to the unaided eye, like smoke noticeable all around. The estimation of turbidity was a vital trial of water quality.

Liquids can contain suspended strong matter comprising particles of a wide range of sizes. While some suspended material will be sufficiently enormous and weighty enough to settle quickly to the lower part of the holder if a fluid example is passed on to stand (the settleable solids), tiny particles will settle without a doubt, gradually or not in any manner if the example is routinely upset or the particles are colloidal. These little strong particles cause the fluid to seem turbid.

2.6.4 TSS estimation

TSS was estimated by the stove dry technique utilizing the drying broiler. China dish and channel paper were first dried and note their underlying load on the weight balance as displayed in fig. 50 ml arrangement of the example from a holder is taken in a receptacle, shake well and afterwards pass it toss the channel paper to the dish china dish. Spot this channel paper and china dish in the drying broiler and set the temperature of the stove at 105 C0. Following 24 hours, gauge the channel paper and china dish once more. Then, at that point, TSS esteem is acquired by applying the equation given underneath

$$TSS (mg/L) = \frac{W_a - W_b(g)}{\text{Sample volume (mL)}} \times 10^6$$

W_a = weight of Filter paper + residue (g),

W_b = weight of Filter paper (g)

Figure 5: TSS measurement

3. RESULTS AND DISCUSSION

3.1 Physical examination

3.1.1 Total dissolved solids (TDS)

TDS of all the samples was measured using the standard procedures as mentioned in chapter 3. Readings were taking in replicates of three. The observed values of TDS (Avg. value) of all the samples were mentioned in table 3. In case of control experiment no prominent reduction of TDS was observed as it was only 13 percent after 6 days of retention time. The percentage reduction for water lettuce treatment was observed as 13% and 32% after 3 days and 6 days respectively.

Almost same behavior was seen in case of water hyacinth as 18% and 37% removal of TDS was found after 3 days and 6 days respectively. The maximum removal rate was observed after treatment with the composite of water lettuce and water hyacinth. After 3 days and 6 days the removal rates were 22% and 35% respectively.

Table 3: TDS measurement for different treatment options

Treatment	Days	TDS (mg/L)
T ₀	0 day	2287
	3 day	2109
	6 day	1990
T ₁	0 day	2290
	3 day	1987
	6 day	1560
T ₂	0 day	2290
	3 day	1887
	6 day	1360
T ₃	0 day	2290
	3 day	1787
	6 day	1260

Figure 3 depicts the removal behavior of TDS by different treatment options. That shows a clear decline for T₃ that is the maximum removal was achieved using this combination of treatment.

Figure 6: Removal rates of TDS by different treatments

3.1.2 Turbidity

Turbidity of all the samples was measured using the standard procedures as mentioned in chapter 3. Readings were taking in replicates of three. The observed values of turbidity (Avg. value) of all the samples were mentioned in table 4. In case of control experiment less rate reduction of Turbidity was observed with respect to the other treatments as it is 50 percent after 6 days of retention time. The percentage reduction for water lettuce treatment was observed as 30% and 58% after 3 days and 6 days respectively. Almost same behavior was seen in case of water hyacinth as 38% and 60% removal of turbidity was found after 3 days and 6 days respectively. The maximum removal rate was observed after treatment with the composite of water lettuce and water hyacinth as after 6 days the removal rate was 65%.

Table 4: Turbidity measurements for all treatments		
Treatments	Days	Turbidity(mg/L)
T ₀	0	165
	3	135
	6	97
T ₁	0	161
	3	95
	6	67
T ₂	0	163
	3	101
	6	65
T ₃	0	159
	3	96
	6	55

Figure 7 represents the graphical demonstration of the decreasing rate of turbidity. As the removal rate in T₀ is less as compared to other treatments but the curve of T₃ depicts the maximum removal of the turbidity.

Figure 7: Removal rates of turbidity

3.1.3 Temperature

Temperature of all the samples was measured using the standard procedures as mentioned in chapter 3. Readings were taking in replicates of three. The observed values of temperature (Avg. value) of all the samples are mentioned in table 5. It can be seen in figure 8 that the temperature variation rates of all the treatments are almost same. No significant change in their trends was observed.

Table 5: Temperature measurements for all treatments		
Treatments	Days	Temperature
T ₀	0	35.6
	3	30.3
	6	32.9
T ₁	0	35.2
	3	29.7
	6	32.7
T ₂	0	35.3
	3	29.6
	6	32.8
T ₃	0	35
	3	30.2
	6	32.8

Figure 8: Temperature variation rates

3.2 Chemical examination

3.2.1 pH examination

pH of all the samples was measured using the standard procedures as mentioned in chapter 3. Readings were taking in replicates of three. The observed values of pH (Avg. value) of all the samples are mentioned in table 5. In case of control experiment no prominent reduction of Ph was observed as it is only 16 percent after 6 days of retention time. The percentage reduction for water lettuce treatment was observed as 19% and 33% after 3 days and 6 days respectively.

Table 6: pH measurements for all treatments		
Treatments	Days	pH
T ₀	0	9.32
	3	8.6
	6	7.9
T ₁	0	9.39
	3	7.6
	6	6.16
T ₂	0	9.3
	3	7.1
	6	6.2
T ₃	0	9.33
	3	6.8
	6	6.1

Almost same behavior was seen in case of water hyacinth as 23% and 33% removal of pH was found after 3 days and 6 days respectively. The removal rate observed after treatment with the composite of water lettuce and water hyacinth after 3 days and 6 days were 27% and 33% respectively which is almost same.

Figure 8 depicts that in control treatment, no significant variation in pH but the curves of other three treatments show some variation in the pH level of water after 6 days but curves also show that these three treatments have almost same behaviour of declination after 6 days.

Figure 9: Variation rates of pH

3.2.2 Electrical conductivity (EC)

EC of all the treatments was measured using the standard procedures as mentioned in chapter 3. Readings were taking in replicates of three. The observed values of EC (Avg. value) of all the samples were mentioned in table 6. In case of control experiment no prominent reduction of EC was observed as it is only 12 percent after 6 days of retention time. The percentage reduction for water lettuce treatment was observed as 15% and 27% after 3 days and 6 days respectively. Almost same behavior was seen in case of water hyacinth as 18% and 30% removal of TDS was found

after 3 days and 6 days respectively. The maximum removal rate was observed after treatment with the composite of water lettuce and water hyacinth. After 3 days and 6 days the removal rates were 20% and 35% respectively.

Table 7: EC measurements for all treatments

Treatments	Days	EC(μ S)
T ₀	0	2530
	3	2368
	6	2225
T ₁	0	2530
	3	2150
	6	1839
T ₂	0	2510
	3	2030
	6	1753
T ₃	0	2511
	3	2010
	6	1630

In figure 10, the curves show the graphical representation of the declination rates of electrical conductivity. Blue curve is for control treatment which show no prominent variation. The maximum variation is shown by the purple curve which involves the composite of both plants for treatment.

Figure 10: Removal rates of EC

4. CONCLUSIONS

Water hyacinth and water lettuce was found to be very effective for the treatment of wastewater. Mostly the drains have large amount of the loads of wastewater pollutants and later this water can be used for the irrigation. Our aim was to treat the wastewater by phytoremediation to that level so that it can be safely disposed in the drain to reduce the wastewater load in drains. The results of the experiment concluded that the removal efficiency of both the aquatic plants were significant, and it can be safely disposed in drains. Moreover, this experiment treatment the wastewater

at a very low cost with good removal rates. So, this study was proved to be an efficient and less costly for the removal of TDS, TSS, pH, Turbidity and EC using phytoremediation technique.

REFERENCES

- Abbas, Z., F. Arooj, S. Ali, I.E. Zaheer, M. Rizwan and M.A. Riaz. 2019. Phytoremediation of Landfill Leachate Waste Contaminants Through Floating Bed Technique using Water Hyacinth and Water Lettuce. *International Journal of Phytoremediation*. 21:1356-1367.
- Abinaya, S., R. Saraswathi, S. Rajamohan and S. Mohammed. 2018. Phytoremediation of Total Dissolved Solids (TDS) by *Eichhornia Crassipes*, *Pistia Stratiotes* and *Chrysopogon Zizanioides* from Second Stage RO-Brine Solution. *Res. J. Chem. Environ.* 22:36-41.
- Adler, P.R., S.T. Summerfelt, D.M. Glenn and F. Takeda. 2003. Mechanistic Approach to Phytoremediation of Water. *Ecological Engineering*. 20:251-264.
- Ajayi, T.O. and A.O. Ogunbayo. 2012. Achieving Environmental Sustainability in Wastewater Treatment by Phytoremediation with Water Hyacinth (*Eichhornia crassipes*). *Journal of Sustainable Development*. 5:80.
- Akansha, J., P. Nidheesh, A. Gopinath, K. Anupama and M.S. Kumar. 2020. Treatment of Dairy Industry Wastewater by Combined Aerated Electrocoagulation and Phytoremediation Process. *Chemosphere*. 126652.
- Barac, T., S. Taghavi, B. Borremans, A. Provoost, L. Oeyen, J.V. Colpaert, J. Vangronsveld and D. van der Lelie. 2004. Engineered Endophytic Bacteria Improve Phytoremediation of Water-Soluble, Volatile, Organic Pollutants. *Nature Biotechnology*. 22:583-588.
- Borker, A.R., A.V. Mane, G.D. Saratale and G.R. Pathade. 2013. Phytoremediation Potential of *Eichhornia Crassipes* for the Treatment of Cadmium in Relation with Biochemical and Water Parameters. *Emirates Journal of Food and Agriculture*. 443-456.
- Chen, J., Q. Nie, Y. Zhang, J. Hu and L. Qing. 2014. Eco-Physiological Characteristics of *Pistia Stratiotes* and its Removal of Pollutants from Livestock Wastewater. *Water Science and Technology*. 69:2510-2518.
- de Alkmin, G.D., C. Paisio, E. Agostini and B. Nunes. 2020. Phytoremediation Processes of Domestic and Textile Effluents: Evaluation of The Efficacy and Toxicological Effects in *Lemna Minor* and *Daphnia Magna*. *Environmental Science and Pollution Research*. 27:4423-4441.
- Dhanwal, P., A. Kumar, S. Dudeja, V. Chhokar and V. Beniwal. 2017. Recent Advances in Phytoremediation Technology. *Advances in Environmental Biotechnology*. 227-241.
- Ebel, M., M.W. Evangelou and A. Schaeffer. 2007. Cyanide Phytoremediation by Water Hyacinths (*Eichhornia crassipes*). *Chemosphere*. 66:816-823.