ISSN 2229-5518

Comparative Analysis of *Hydrocotyle umbellata, Pistia stratiotes* & *Eichhorina crassipess* for the Removal of Contaminants in Domestic Wastewater

[1]Haroon Ur Rasheed, [2]Bilawal Rasheed, [1]Naureen Aurangzeb, [2]Dr. Ayub khan and [1]Dr. Ahmad Hussain

[1]*Department of Environmental Sciences, University of Haripur, Khyber Pakhtunkhwa, Pakistan*

[2]*Department of Agriculture Sciences, University of Haripur, Khyber Pakhtunkhwa, Pakistan*

Abstract

The aim of the present study was to determine the performance of aquatic macrophytes in the treatment lagoons at NARC, Islamabad. The analytical procedure given by APHA (2005) was followed for the determination of physical parameters (pH, EC and TDS) and chemical parameters (Cl^{-1}, SO_2^{-1} and NO_3^{-1}) of the domestic wastewater. Rhizofilteration efficiency of the experimental plants was in sequence as *Pistia stratiotes>Eichhornia crassipess>Hydrocotyle umbellatta* at average temperature of 33°C while *Pistia stratiotes* and *Eichhornia crassipess* showed maximum removal efficiency at 31°C whereas *Hydrocotyle umbellatta* at 35°C. This biologically treated domestic wastewater can be used for irrigating farmlands and parks.

Keyword: *Hydrocotyle umbellata, Pistia stratiotes, Eichhorina crassipess, c*ontaminants, domestic, wastewater

Introduction

Domestic waste containing household effluent and human waste is either discharged directly to sewer system, natural drain, water body, a nearby field or an internal septic tank. Pakistan, an agriculture-based country once had surplus water, is currently a water deficit country as per capita water availability in 1951 was 5300 m^3 but recently reduced to 1105 m^3, just touching the water scarcity level of 1000 m^3 (SOER, 2005).Out of the total available fresh water 88% alone is used for irrigation (Gleick, 2000). Pakistan has a total of 77 million acres of land suitable for irrigation out of which 71% is already cultivated, but the remaining 29% can become dynamic if water made available for irrigation (PIDAT, 2003). Therefore, the country is in dire need to sustainably use and conserve this precious resource. The 3R principle of reuse, recycle and reduce may be helpful in achieving the objectives as ten large urban centers of Pakistan produces more than 60% of the total urban wastewater including household, industrial and commercial wastewater (WB-CWRAS, 2005) out of which only 8% is treated in municipal treatment plants (Feestra *et al.*, 2005).

Domestic waste water contain various chemicals promotes plant / crop growth when present in permissible limits. During the last two last decades, the reuse of treated water for irrigation has exhausted, particularly in arid and semi- arid regions. Wastewater has usually the higher quantity of these chemicals which adversely affect the soil, crops quality (Khwakaram, 2010). Nitrate is an important constituent of chlorophyll, protoplasm, protein, amino acids, nucleic acid and growth hormones. An excess of nitrate leads to more vegetative growth and cause lodging. Excessive nitrate contents, higher than 100 mg/litre, may affect transplants and sensitive crops at the initial growth stage (WHO, 2004). Serious public health problems rose due to the use of wastewater. Wastewater carries a wide range of pathogenic organisms posing a risk to agriculture workers, crop handlers and consumers. High level of nitrogen in wastewater results in nitrate pollution of groundwater, which could lead to adverse effects on human health (Blumenthal *et al*., 2001).

Chloride helps plants to metabolize. The accumulated chloride concentration in leaves exceeds the crop's tolerance, injury symptoms develop in the form of leaf burn. This starts at the tips of leaves and progresses from the tip back, along the edges, as the severity increases. In extreme cases chloride toxicity manifests itself in early leaf drop. Crop quality is affected by chloride-induced leaf injury in plants whose leaves are the marketed product, or where fruit size and appearance are affected by chloride-induced yield decreases (Imran, 2005).

Sulfate is used for protein synthesis, enzyme reaction and energy transfer. A plant injured by excessive sulfate first displays mottled leaves or yellowed tissue between the veins of leaves. This is followed by leaves that are dead at their tips, at their margins, and in areas between their veins. Excessive sulfate concentration may lead to laxative effect and it affects the alimentary canal (Purushotham *et al*., 2011).

Hydrocotyle umbellatta common name is pennywort belongs to family Apiaceae. It is free-floating aquatic plant. It reproduces from fragments and seeds and can spread across the soil or water in large mats (Afrous *et al.*, 2010). *Pistia stratiotes* common name is water lettuce belongs to family Araceae. It is free-floating aquatic plant. It is a free- floating plant that is capable of forming dense mats on the surface of lakes, ponds, rivers and other bodies of water (Moore, 2005). *Eichhorina crassipess* common name is water hyacinth belongs to family Pontederiaceae. It is free-floating aquatic plant. Cold-damaged leaves then fold down and protect the meristem, which grows at or immediately below the surface of the water (Hussain *et al.,* 2010).

Methodology

Sampling: The experiment was carried out in an aerobic treatment lagoons in natural environment, sample of wastewater was collected from all bio-treatment ponds. From each pond, samples were collected three times. Water samples were collected directly from inlet and outlet of each pond during subsequent days, 10, 20 and 31 days. Mechanism of treatment is exclusively based on bio-remediation i.e. using indigenous plants and microbes. Table (i) shows the dimension and water storing capacity of different ponds.

Table (i) Dimension of treatment lagoons

Plants	Length (ft)	Width (ft)	Depth (ft)	Storage Capacity (m.gal)
Pistia stratiotes	97	83	6.5	0.40
Eichhornia crassipess	98	80	6.5	0.40
Hydrocotyle umbellatta	98	82	6.5	0.40

Wastewater sampling and physio-chemical analysis: For sample collection the bottles were washed with hot water followed by distilled water. During collection bottles were filled, rinsed with the sample water 2-3 times, tightly capped and properly labeled (APHA, 2005). Physical parameters of collected water samples were studied immediately, which were collected in replicates from all the bio-treatment ponds. In physical parameters analysis pH, EC and TDS were studied. While Chloride, Sulfate and Nitrate were the chemical parameters which were studied. Analytical procedure given by APHA (2005) used for water analysis. The pH of the wastewater determine by pH meter (WA-2015). Electric conductivity determined by conductivity meter (WA-2015). Total Dissolved Solids determined by TDS Meter (WA-2015). Chloride determined by titration method given by APHA.

$$Cl^{-1} = \frac{\text{ml of titrant used} \times N \times 35.5 \times 1000}{20}$$

The UV-visible method used for the rough estimate of Nitrate. It determined the absorption of nitrate ion at 220 nm. UV/VIS spectrophotometer (Lambda 3B) used for analysis. The UV-visible method used for the rough estimate of Sulfate. It determined the absorption of nitrate ion at 420 nm. UV/VIS spectrophotometer (Lambda 3B) used for analysis.

Results & Discussion

Each parameter is analyzed 3 times, results shown in Table (ii). Sample was collected from Bio-remediation Orchard. Efficiency of these macrophytes in scavenging contaminants designate that the presence of these macrophytes was vital constituent for the removal of contaminants in the wastewater. Following are the different results shown by macrophytes. pH decreased by *Pistia stratiotes* 3.7%, 5% and 6.3%. *Eichhornia crassipess* also decreased pH by 1.3%, 2.5% and 5%. *Hydrocotyle umbellatta* increased pH by 5%, 2.5% and 2.1%.

Pistia stratiotes show better results at 31 ^oC as compare to 33 ^oC and 35 ^oC. EC decreased by *Pistia stratiotes* by 5.3% at 31 ^oC. *Eichhornia crassipess* showed comparatively good results at 31^oC. *Eichhornia crassipess* decreased EC by 1.6% at 31 ^oC. EC decreased by *Hydrocotyle umbellatta* by 1.5%, at 35 ^oC.

Greater accumulatation of TDS showned by *Pistia stratiotes* and decreased TDS by 4% at 31 ^oC rather than 1.3% decreased at 35 ^oC. *Eichhornia crassipess* decreased TDS by 3% at 31 ^oC . But *Hydrocotyle umbellatta* decreased TDS by 2.2% at 35 ^oC.

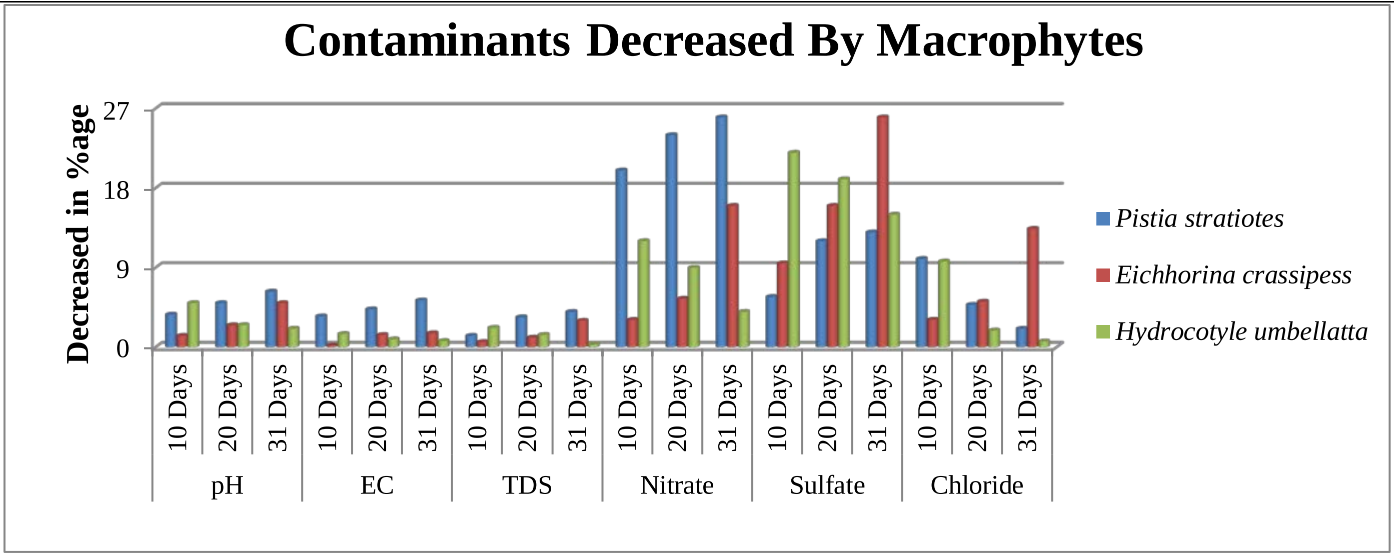
Nitrates decreased by *Pistia stratiotes* by 26% at 31 ^oC respectively. *Eichhornia crassipess* decreased Nitrates by 16% at 31 ^oC . *Hydrocotyle umbellatta* decreased Nitrates concentration by 12% at 35 ^oC.

Sulfate decreased 13% by *Pistia stratiotes* at 31 ^oC. *Eichhornia crassipess* decreased Sulfate by 26% at 35 ^oC. *Hydrocotyle umbellatta* decreased Sulfate by 22% at 35 ^oC, 33 ^oC and 31 ^oC.

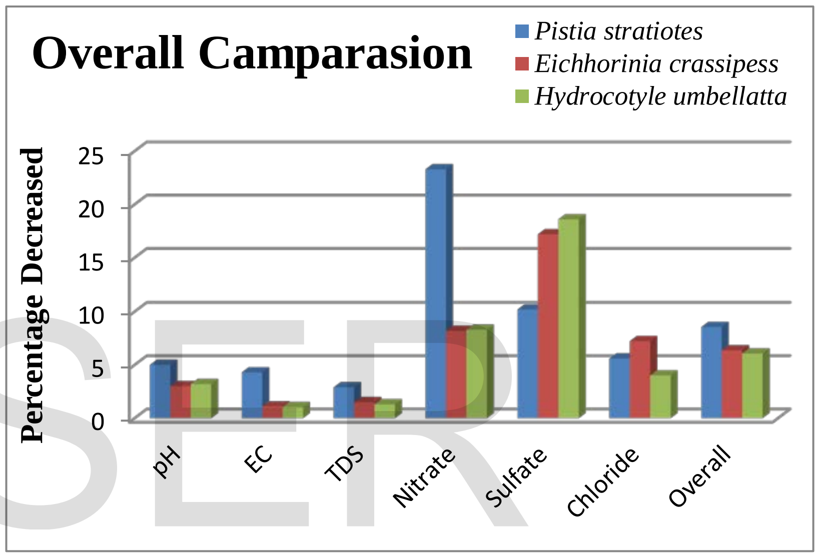
Chloride decreased by 10% by *Pistia stratiotes* at 35 ^oC. *Eichhornia crassipess* decreased Chloride by 13.4% at 31 ^oC respectively. *Hydrocotyle umbellatta* decreased Chloride by 9.7% at 35 ^oC.

Averages of all the percentages decreased by *Pistia stratiotes* at temperature 35 ^oC was 7.3, 33 ^oC was 8.9 and at 31 ^oC was 9.45.This showed that its best performance at 31 ^oC as compare to other temperature. So overall performance of *Pistia stratiotes* comparatively higher than *Eichhornia crassipess and Hydrocotyle umbellatta.*

Averages percentages decreased by *Eichhornia crassipess* at 35 ^oC, 33 ^oC and 31 ^oC was 2.97, 5.27 and



10.8. This showed that likewise *Pistia stratiotes*, *Eichhornia crassipess* showed maximum accumulation at 35 ^oC. But overall performance of *Eichhornia crassipess* in month July is less than *Pistia stratiotes* but higher than *Hydrocotyle umbellatta*.



Hydrocotyle umbellatta showed maximum accumulation at 35 ^oC but other species showed maximum accumulation at 31 ^oC. Averages of percentages showed that 8.7, 5.78 and 3.79 decreased by *Hydrocotyle umbellatta* at temperature 35 ^oC, 33 ^oC and 31 ^oC respectively. And its performance is at least as compare to both of other plants.

Analysis of all these species indicates that accumulation of *Pistia stratiotes* is greater than other, then *Eichhornia crassipess* and least accumulates done by *Hydrocotyle umbellatta.*

Conclusion

Presently Pakistan is facing a scarcity of freshwater resources and per capita water availability which was 5300 m^3 in 1951 had reduced to 1105 m^3. However, Agriculture is the single largest user of fresh water in the world, in Pakistan nearly 88% fresh water used for irrigation. This study will help to make better choice of wastewater plant system for other cities of Pakistan because this technology is not expensive and easy to adopt. The ponds are suitable as fish farms and we can use this water for crops and farming.

The main reasons for declining water availability are rapid growth and pollution/contaminants of existing water resources due to discharge of untreated industrial and sewage effluents into streams/rivers. Deterioration of water quality of lakes, rivers and groundwater aquifers has resulted in increased waterborne diseases and other health impacts.

Recommendations

The demand for increased water supply in the city continues day by day due to continued growth of population and also due to development programs for a better socio-economic standard. The Government so far has failed to meet the short fall in water supply for both domestic and industrial purposes. The cost of water that is already in short supply is also increasing thereby increasing the cost of production. Water should be regarded as a gift of God and nature and must be handled with extreme care and never be misused. However, it is the most misused commodity on earth. Due to continued shortage of water and ever increasing cost it is logical to recycle it wherever possible/feasible.

Phytoremediation can occur naturally, it is more effective when good design, planting, and site management processes are carried out properly. Treated water has some of organic compounds and also micronutrients which are required for better crop yield, it is good for soil.

Table (ii). Physico/Chemical Analysis of Wastewater in the Month July at Bio-remediation Orchard

Date/ Temp	Plants	Physical Parameters									Chemical Parameters								
		pH			EC (dS/m)			TDS (NTU)			NO_3^{-1} (ppm)			SO_4^{-1} (ppm)			Cl^{-1} (ppm)		
		In	Out	Diff	In	Out	Diff	In	Out	Diff	In	Out	Diff	In	Out	Diff	In	Out	Diff
9th July, 2012 (35°C)	Water Lettuce	8.0	7.7	3.7*	1.13	1.09	3.5*	740	730	1.3*	3.9	3.1	20*	69	65	5.7*	50	45	10*
	Water Hyacinth	7.6	7.5	1.3*	1.091	1.089	0.2*	697	693	0.6*	3.2	3.1	3.1*	63	57	9.5*	43.4	45.0	3.12*
	Water Pennywort	7.5	7.9	5*	1.098	1.081	1.5*	697	681	2.2*	3.1	2.7	12*	68	53	22*	52.1	47	9.7*
19th July, 2012 (33°C)	Water Lettuce	8.0	7.6	5*	1.16	1.11	4.3*	773	746	3.4*	3.7	2.8	24*	71	62	12*	62.12	59.09	4.8*
	Water Hyacinth	7.8	7.6	2.5*	1.052	1.037	1.4*	688	681	1.1*	2.75	2.6	5.5*	66	55	16*	46.0	52.1	5.17*
	Water Pennywort	7.5	7.7	2.5*	1.052	1.042	0.9*	701	691	1.4*	2.75	2.5	9*	68	55	19*	60.2	58.8	1.9*
30th July, 2012 (31°C)	Water Lettuce	8.1	7.58	6.3*	1.162	1.10	5.3*	770	739	4*	4.1	3	26*	67	58	13*	61.4	60.1	2.1*
	Water Hyacinth	7.9	7.5	5*	1.109	1.091	1.6*	680	659	3*	2.9	2.5	16*	69	51	26*	60.2	59.6	13.4*
	Water Pennywort	7.7	7.9	2.1*	1.098	1.091	0.7*	697	695	0.3*	2.51	2.4	4*	60	51	15*	45	44.7	0.66*

* = %
In = Inlet
Out = Outlet
Diff = Difference

A permissible limit of agriculture for pH is (6.5-8.5), EC is (0-3 dS/m), TDS is (0-2000 NTU), Cl^{-1} is (0-1065ppm), NO_3^{-1} is (0-30ppm) and SO_4^{-2} is (0-960ppm) given by United States Department of Agriculture (APHA).

ISSN 2229-5518

Literature Cited

Afrous A., Goudarzi S & Liaghat A. 2010. Phytoremediation by some Species of Aquatic Plants for as and Hg Removal. Azad University. Dezful. Iran. J. Advances in Environ. Bio. 5(11):3629-3635.

APHA. 2005. Standard Methods for The Examination of Water and Wastewater Analysis (21st ed.) American Public Health Association, American Water Works Association.

Blumenthal U. J., Cifuentes E., Bemett S., Quigley M & Ruiz-Palacouis G. 2001. The Risk of Enteric Infection Associated with Wastewater Reuse: The Effect of Season and Degree of Storage of Wastewater. Transactions of the Royal Society of Tropical Medicine and Hygiene.

Pakistan Institute of legislative Development and Transparency (PIDAT) 2003. Issue of Water Resources in Pakistan. Briefing Paper for Pakistani Parliamentarians. Briefing paper No. 7.

Feenstra S., Hussain R & Van der Hoek W. 2005. Health Risks of Irrigation with Untreated Urban Wastewater in Southern Punjab. Pakistan IWMI Pakistan Report 107. Lahore. Pakistan.

Gleick P. H. 2000. The World’s Water 2000–2001: The Biennial Report on Freshwater Resources. Island Press. Washington. DC. USA.

Hussain T. S., Mahmood T & Malik S. A. 2010. Phytoremediation Technologies for Ni^{++} by Watrer Hyacinth. African J. of Biotechnology. 9(50): 8648-8660.

Hoek W. V., Hassan M., Ensink J. H. J., Feenstra S., R-Sally L., Munir S., Aslam R., Ali N., Hussain R & Mastuno Y. 2002. Urban Wastewater: A Value Resource for Agriculture. A Case Study from Haroonabad, Pakistan. Research Report 63. International Water Management Institute.

Imran H. 2005. Wastewater Monitoring of Pharmacuutical Industry: Treatment and Reuse Options. Electron. J. Environ. Agric. Food Chem. Islamabad. Pakistan.

Khwakaram I. A & Ganjo D. G. A. 2010. Phytoremediation of Wastewater Using Some of Aquatic Macrophytes as Biological Purifiers for Irrigation Purposes. World Academy of Sci. Engg. & Tech. 66.

Moore G. R. 2005. The Role of Nuterients in The Biological Control of Water Lettuce, Pistia stratiotes Lamarck(Araceae) by The Leaf-Feeding Weevil, Neohydronmous affinis Hustache (Coleoptera: Curculionidae) With Particular Reference to Eutrophic Condition. Rhodes University, Grahamstown.

Purushotham D., Narsing Rao. A., Ravi Prakash M., Ahmed S & Ashok Babu G. 2011. Environmental Impact on Groundwater of Maheshwaram Watershed, Ranga Reddy district. Andhra Pradesh. J. Geological Society of India. 77 (6): 539-548. ISSN 0016-7622.

State of the Environment Report 2005 (SOER). Ministry of Environment, Government of Pakistan.

WHO. 2004. Rolling Revision of The WHO Guidelines for Drinking-water Quality, Draft for review and comments. Nitrates and Nitrites in drinking-water. World Health Organization.

World Bank. 2005. Pakistan Country Water Resources Assistance Strategy Water Economy. Running Dry (WB-CWRAS).