International Journal of Civil Engineering and Technology (IJCIET)
Volume 8, Issue 8, August 2017, pp. 1413–1421, Article ID: IJCIET_08_08_155
Available online at http://http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=8&IType=8
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

WASTEWATER TREATMENT USING CONSTRUCTED WETLAND WITH WATER LETTUCE (EICHORNIA CRASIPIES)

Aswathy. M
Assistant Professor, Department of Civil Engineering,
BIHER, Bharath University, Chennai, India

ABSTRACT

A wetland was constructed in a laboratory-scale at the Department of Civil Engineering; Sree Chitra Tirunal College of Engineering which was established in April 1969 to demonstrate the gravel- based constructed wetland, using Water Lettuce. The experiment was carried out to demonstrate the enhanced removal efficiency for Water lettuce with constructed wetland in treating kitchen wastewater, from a nearby Campus restaurant. A retention period of ten days was chosen for the performance evaluation of the constructed wetland. Water Lettuce had improved the wastewater quality significantly as it had reduced 85.66% of Turbidity, BOD5 by 83.43%, No-3 by over 50%, 90% of SO-4, 46.2% of Cl- and Conductivity by 46.2% and Dissolve Oxygen by 58%. The pH increased by 23%, while the initial offensive odour of the raw water was reduced considerably.

The effluent from the wet land was found useful in irrigation and keeping aquatic animals. However, it was noted that a 6- day detention time was found optimized for the treatment kitchen waste water. The the construction and maintenance cost involved was very minimal an so the treatment system was found to be more economical, as. The effluent was free from offensive odour and insect invasion.

Key words: Constructed Wetland, Canteen Wastewater, Laboratory Scale, Nutrient Removal, Retention Period, Water Hyacinth.

Cite this Article: Aswathy. M, Wastewater Treatment Using Constructed Wetland with Water Lettuce (Eichornia Crasipies). International Journal of Civil Engineering and Technology, 8(8), 2017, pp. 1413–1421.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=8&IType=8

1. INTRODUCTION

Constructed wetlands are engineered to duplicate the processes occurring in natural wetlands, where the main purpose of the structure is to remove the contaminant or pollutant from the wastewater. The constructed wetland is an integrated system consisting of water, plants, microorganisms and the environment, in which can be manipulated to improve water quality. The constructed wetland is a new green technology, which has been recognized and accepted as a creative, cost-effective and environmental friendly system when compared to the expensive conventional treatment systems. The constructed wetlands, has been recently used for wastewater treatment in many sectors. Thus, an extensive research and practical application is being gained in order to operate the system effectively.

For storm water purification, constructed wetlands has wide application in the recent decades, along with domestic, agricultural, and also industrial wastewater treatment. The use of constructed wetland on industrial pollutants is increasingly utilized and these represent a promising alternative method to treat the various types of industrial wastewater using the new technology of constructed wetlands In recent years, increasing production and disposal of wastewater have caused an accelerated pollution of receiving water bodies. Hence, to reduce the harmful impact of the wastewater discharge, there is the need to remove the main nutrients such as nitrogen and phosphorus as well as the organic content of the wastewater prior to disposal. This can be effectively achieved by the conventional treatment technology, but the working expenses and energy requirements of such treatment systems are rather high and in many cases hinder by economic constraints which often leads to the desertion of such various treatment plants in the country (Nigeria) due to lack of funding and consequently maintenance on the part of the responsible agency. However, several investigations have shown that wetlands may act as efficient water purification systems and nutrient sinks.

Constructed wetlands are artificial wastewater treatment system consisting of shallow (usually less than 1 m deep) ponds or channels, which have been planted with aquatic plants, and rely upon natural microbial, biological, physical and chemical processes to treat wastewater. These systems of wastewater treatment offer several potential advantages as compared to conventional treatment system, this include; simple construction (can be constructed with local materials), require less skill to operate and maintain, process stability under varying environmental conditions, Utilization of natural processes, and lower construction, operation and maintenance costs. There are two basic types of constructed wetland namely; free water surface flow constructed wetland in which the flow of water is above the sediment surface, and subsurface flow constructed wetland in which the flow of water is primarily below the sediment surface. These systems use wetland plants, soils and their associated microorganisms to remove contaminants from wastewater. The pollutant removal mechanisms in a constructed wetland plant comprise several physical, chemical, biological and biochemical processes and this include; sedimentation, filtration, aerobic and anaerobic microbial degradation, plant uptake, soil sorption, precipitation and so on .

Water lettuce is important in the treatment of waste water. The use of water plants in waste water treatment is economical, is a natural way of treating water. Water lettuce is a free-floating aquatic weed that rapidly forms dense mats covering rivers, dams and irrigation canals. It can restrict water flow, increase water loss by transpiration and serve as a breeding ground for mosquitoes. Water lettuce spreads both by vegetative reproduction and by seeds. The treatment system is vegetated with water lettuce (Pistia stratiotes) plant with different experimental conditions. The test in the laboratory, the water sample would be taken from the planting area which consists of water lettuce (Pistia stratiotes) that is planted in the container and which is then filled with waste water. There are more than nine parameters that would be analyzed in the laboratory to determine the physical and chemical characteristics of the waste water which are;

Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), Temperature, Oxidation reduction potential (ORP), Colour, Dissolved oxygen (DO), pH, Turbidity, Total dissolved solids (TDS), calcium (Ca), Magnesium (Mg), Chloride (Cl), Sulphite, Nitrite (NO3), Iron (Fe), Conductivity, Hardness, Zinc and Calcium. The scope of work for this project is to investigate the removal efficiency of the aforementioned physical and chemical properties by using different number of water lettuce (Pistia stratiotes) and to record the sampling of the waste water for a detention period of 10 days.

2. MATERIAL AND METHODS

A. Study Site

The laboratory scale wetland was set-up at the Department of Civil Engineering in Sree Chitra Thirunal College of Engineering which was established in April 1969. The town is characterized by an average daily temperature of between 25^{o} and 35^{o} almost throughout the year.

B. Experimental Setup and Operation Condition of Wetland

The constructed wetland filled with substrate in a bed enables growth of only selected plants and attached biofilms. Series of physical, chemical and biological processes takes place in the root zone of constructed wetland .Significant reduction in suspended solids, organic compounds is found out**.** The basin was constructed at a height of 300mm and width of 900mm and the bed was prepared and braced so as to avoid bulking of the fabrication. The substrate (soil media) was filled at the base up to 150mm with each layer covering 50mm each. The first layer at the base consists of granite followed by sand and humus soil at the top which were well sieved. Water was being poured layer by layer and after the substrate arrangement the water level was filled up to about 100mm height. The water particles were allowed to settle down before the plant (water hyacinth) was collected from its natural habitat and planted. It was also left for some days to adapt before wastewater was being collected and added for treatment process to commence.

C. Wetland Operation

Draining of the Setup: All the water present in the setup was drained two days before the introduction of the wastewater by keeping the outlet widely open. This is necessary to avoid the dilution of the wastewater by the fresh water used in nurturing the plant and therefore eliminate error during analysis.

D. Wastewater Collection:

The wastewater used for this research work was collected from the canteen waste water area of pappanamcode along Ilorin road with the aid of six 25 liters kegs to make the total volume of the waste water collected 150 liters

E. Pretreatment and Introduction of the Wastewater into the Setup

A total volume of 75 liters of wastewater was screened using a 75µm sieve and introduce into the setup manually from the open roof at top of the basin on 17th of March 2014

F. Sample Collection and Qualitative analysis

75ml sample each was collected from the setup for detention time of 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 days respectively including that of the raw waste water, and qualitative analysis carried out according to APHA standard on each of the sample collected to determine the effect of detention period on the wastewater.

The parameters tested for are: Colour, pH and odour, Temperature, Turbidity, Conductivity, Dissolved Oxygen (DO), Biochemical Oxygen Demand ($BOD_{5, 20}$), Magnesium (Mg), Chloride (Cl^-), Sulphide (SO_4) and Nitrate (NO_3).

Fig. 1 Constructed Wetland Unit

Fig. 2 Wetland Unit with Lining

Fig.3 Gravel Layer

Fig 4 Sand Layer

Fig 5 Humus Layer

Fig.6 Water lettuce Planted

Fig.7 Few Days After

3. RESULTS AND DISCUSSION

A. Results

The results of the Physico-chemical analyses carried out on the samples daily for a retention time of ten (10) days were presented are as shown in Table 1 below.

Table 1 Effluent Characteristics for the Various Detention Periods

Parameters	Detention period										
	0	1	2	3	4	5	6	7	8	9	10
PH	6.24	6.18	6.79	7.13	7.49	7.31	7.60	7.63	7.67	7.41	7.39
Temperature (°C)	29.50	24.20	26.40	24.20	27.40	31.40	28.10	27.40	25.60	26.20	26.80
Redox Potential	88.00	84.00	51.00	32.00	12.00	21.00	7.00	6.00	4.00	18.00	18.00
Turbidity (FTU)	175.00	170.00	89.00	51.00	50.00	49.37	53.00	47.70	42.62	84.00	61.00
Conductivity (µS)	15.80	8.70	14.00	10.50	10.40	11.20	10.50	10.80	8.50	8.60	8.60
DO (ppm)	138.90	120.60	114.50	134.80	193.80	105.60	102.80	104.90	103.4	84.60	58.50
BOD_5 (mg/l)	54.30	54.00	10.50	55.90	55.00	30.10	21.20	53.40	20.80	9.40	8.50
Mg (mg/l)	51.03	0.00	218.70	123.93	109.3	116.64	72.90	72.90	43.74	29.16	14.58
Iron (mg/l)	1.5	3.3	2.3	2.1	3.2	3.6	3.3	3.4	5.1	5.2	4.1
SO_4^-(mg/l)	40	50	14	10	10	10	12	4	4	4	2
NO_3^-(mg/l)	20	10	10	10	10	10	10	10	10	0	0

Table 2
TREATMENT PERFORMANCE OF THE WETLAND PLANT

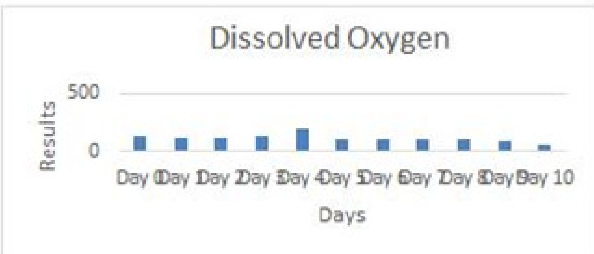
Parameters	Treatment Performance (% Reduction)									
	Detention periods (days)									
	1	2	3	4	5	6	7	8	9	10
PH *	0.96	8.81	14.26	20.03	17.15	21.79	22.28	22.92	18.75	18.43
Temperature	17.97	10.51	17.97	7.12	6.44	4.75	7.12	13.22	11.19	9.15
Redox Potential	4.55	42.05	63.64	86.36	76.14	92.05	93.18	95.45	79.55	79.55
Turbidity	2.86	29.14	70.86	71.43	71.79	69.71	72.74	75.66	52.00	65.14
Conductivity	44.94	11.39	33.54	34.18	29.11	33.54	31.65	46.20	45.57	45.57
DO	13.17	17.57	2.95	39.52	23.97	25.99	24.48	25.56	39.09	57.88
BOD_5	1.85	80.66	2.95	1.29	44.5	60.95	1.66	61.70	82.69	83.43
Mg*	0	328.57	0	114.29	128.57	42.86	42.86	14.29	42.86	71.43
Iron*	200	100	100	200	200	200	200	400	400	300
SO_4^-	25	65	75	75	75	70	90	90	90	90
NO_3^-	50	50	50	50	50	50	50	50	100	100

Note: *Percentage increase

B. Discussion

The pH was seen to increase progressively with a maximum percentage increase of 22.92% occurring at day 8. The Ph of the treated water meets up with WHO standard for drinking water which is between the ranges of 6.4-8.5. It also meets up with the irrigation standard. If Ph is less than 6.5 in crop yield, there would be increased foliar damage and may corrode irrigation equipments. Increase or decrease in temperature may not necessarily mean reduction in level of impurities. The result shows a gradual decrease in the value of the ORP. The maximum % reduction occurs at day 8 (95.45%). Since ORP is the activity or strength of oxidizers and reducers in relation to their concentration. Therefore, ORP value reduces as the pathogenic activities reduce and impurities reduce. DO values are not consistent. However, the values increase as the retention day increases. Maximum % DO occur at day 10 which is 57.88% increase. Increase in DO imparts good taste to water. The result of the analysis shows continuous reduction in the turbidity per day. The maximum percentage reduction of turbidity occurred at day 8. The value of Mg present is not progressively reduced. The content of Mg in the water fluctuates but towards the end, there was a gradual reduction in Mg. The maximum % decrease of Mg is 71.43% at day 10. The nitrite content of the raw water was 20mg/l. The nitrite content reduces from 20mg/l to 0. Nitrite was completely removed at day 9. The result of the analysis shows sulfite being gradually removed as retention day increases. There was 90% removal of sulfite in the waste water at day 7.

The BOD value increases up to day 4. However, progressive reduction of BOD was recorded till the last day (day 10). Reduction in the BOD implies decrease in the microbial activities in water. Iron content of water increases gradually. It was also seen that it is effective for crop yield. The values of conductivity and TDS increased continuously. There was 46.20% increase in day 8 which is the maximum increase recorded. Total dissolved solids (TDS) and conductivity both indicate the total inorganic mineral content of drinking water. Either of these tests can be used to monitor the consistency of quality from water purification processes which remove inorganic contaminants from water. With the exception of the first day, hardness of the water decreases steadily. There was maximum reduction in hardness of the water at day 8. Based on the available data, the desirable minimum of magnesium and calcium is estimated to be > 5 mg/l and > 25-35 mg/l, respectively. This does not mean that if a small increase in the value within the limit will have no effect (e.g. if the magnesium level were increased from 2 to 5 mg/l), it would be of no importance. It means that any increase, even by a small mg/l, could have a serious impact.



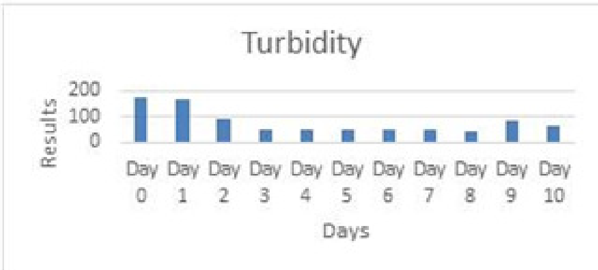


Figure 8, 9 Graph of DO and Turbidity against Retention Days

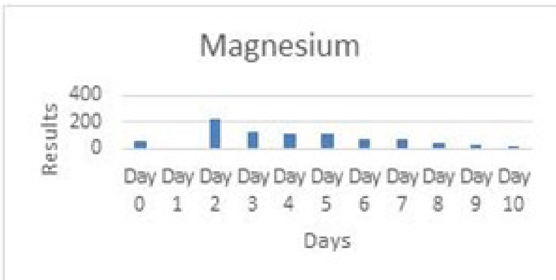


Figure 10, 11 Graph of Mg and nitrite Against Retention Days

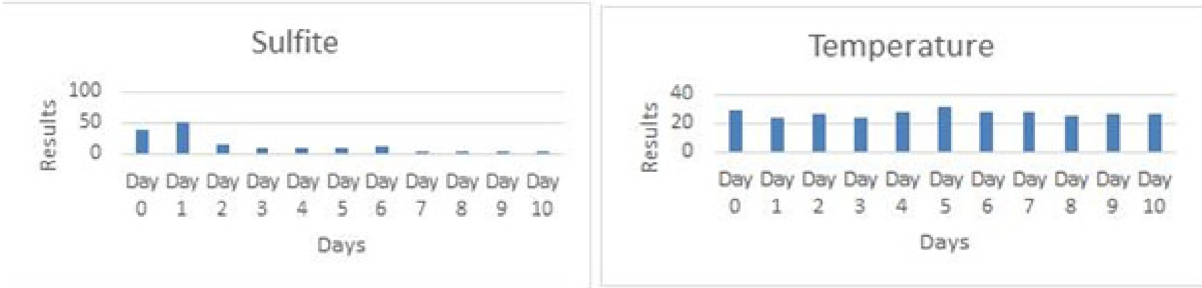


Figure 12, 13 Graph of Temperature and sulfite Against Retention Days

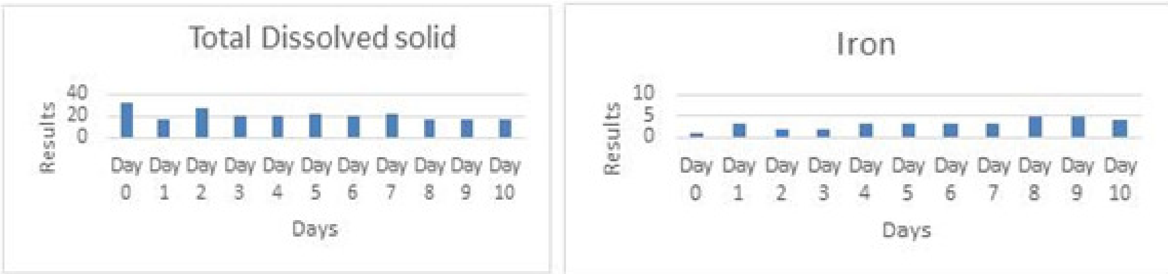


Figure 14, 15 Graph of Fe, TDS against Retention Days

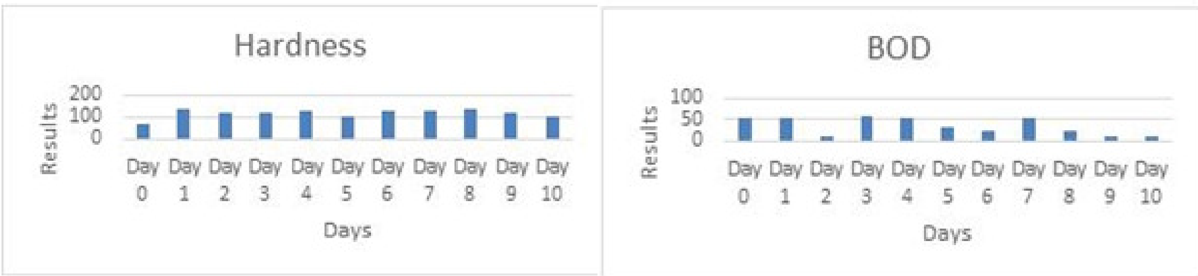


Figure 16, 17 Graph of BOD and hardness Against Retention Days

4. CONCLUSION

This project helps in reducing the pollution parameters before being disposed to water bodies. It also reduces the risk of contaminating underground water. The volume of water lettuce used must cover the whole area of the water, for effective treatment. High level of grease in waste water prevent oxygenation reaction thereby causes plant death. There is progressive reduction in the pollution parameters up till day 8, and reduction is more effective afterwards. Wastewater treatment using water lettuce is highly effective in the removal of nitrite

The container for the experiment should be continuous so as to avoid leakages due to loading i.e. it should not have joining. The effluent can be further treated for domestic uses. The effluent can be used for non- potable purposes like irrigation. The lab wetland should be exposed to sunlight without shed for effective removal of organic element.

REFERENCES

[1] Aremu S.A and Ojoawo S.O (2005).Water hyacinth (*Eichhornia Crassipes*) culture in sewage: nutrient removal and potential applications of bye-products. *Transnational journal of science and technology edition vol. 2, No. 7, pp 103-114*

[2] Dolan, T.J., Bayleys, S.E., Zoltek, J.Jr and Hermann, A.J. (1981). Phophorus dynamic in a Florida marsh receiving treated wastewater.

[3] Brix H. (1987). Treatment of wastewater in the Rhizosphere of wetland plants – The root-zone method. *Wat. Sci. Tech. vol. 19, Rio, pp. 107-118.*

[4] Saritha B., Rajasekhar K., Removal of malachite green and methylene blue using low cost adsorbents from aqueous medium-a review, Middle - East Journal of Scientific Research, v-17, i-12, pp-1779-1784, 2013.

[5] Saritha B., Ilayaraja K., Eqyaabal Z., Geo textiles and geo synthetics for soil reinforcement, International Journal of Applied Engineering Research, v-9, i-22, pp-5533-5536, 2014.

[6] Ilayaraja K., Krishnamurthy R.R., Jayaprakash M., Velmurugan P.M., Muthuraj S., Characterization of the 26 December 2004 tsunami deposits in Andaman Islands (Bay of Bengal, India), Environmental Earth Sciences, v-66, i-8, pp-2459-2476, 2012.

[7] Ilayaraja K., Ambica A, Spatial distribution of groundwater quality between Injambakkam-Thiruvanmyiur Areas, South East Coast of India, Nature Environment and Pollution Technology, Volume 14, Issue 4, pp-771-776, 2015.

[8] Brix H. (1993). Wastewater treatment in constructed wetlands: system design, Removal process, and treatment performance. *Moshiri GA (ed): constructed wetlands for water quality improvement. Lewis publishers, chapter 2, pp 9-21*

[9] Vinita V., Singh U R, Billore S K. (2008). Efficacy of rootzone technology for treatment of domestic wastewater: field scale study of a pilot project in Bhopal. (MP), India. Proceedings of Taal2007: the 12th world lake conference, pp 995-1003

[10] Jun-Jun Chang, Su-ging Wu, Yan-ran Dai, Wei Liang and Zhen-bin Wu. (2006). Treatment performance of integrated vertical-flow constructed wetland plots for domestic waste water. Ecological Engineering, 44 (2012,) 152– 159.

[11] Sandeep T. Tayade, Ajay R. Ojha, Rakesh Kumar and Singh, R.N. (2005). Feasibility study of constructed wetland for treatment of municipal wastewater.

[12] Baskar G., Deeptha V.T. and Abdul Rahaman A. (2008). Root zone technology for campus waste water treatment. *Journal of environmental research and development vol.3 no.3, pp 695-705.*

[13] Borkar. R.P. and Mahatme P.S. (2006) Wastewater treatment with vertical flow constructed wetland. *International journal of environmental science volume 2, No 2, pp. 590-603*

[14] UN-Habitat, (2008). Constructed wetlands manual. UN-HABITAT water for Asian cities programme Nepal, Kathmandu. Pp 3-13

[15] Brix H., (2003). Plant used in constructed wetlands and their functions. Ist international seminar on the use of aquatic macrophytes for wastewater treatment in constructed wetlands

[16] Piyush G., Surendra R. and Amit B.M. (2008). Treatment of water using water Hyacinth, water lettuce and vetiver grass- A review. *Resources and environment, 2(5), pp 202-215.*

[17] USEPA (1988). Constructed wetlands and aquatic plant systems for municipal wastewater treatment. *U.S. design manual.* United States Environmental Protection Agency.

[18] Sandhiya K., Kaviya B., Safe bus stop location in Trichy city by using gis, International Journal of Applied Engineering Research, v-9, i-22, pp-5686-5691, 2014.

[19] Ali H. Al-Aboodi, Husham T.Ibrahim and Sarmad A.Abbas, Performance of Sequencing Batch Reactor (SBR) for Domestic Wastewater Treatment Under Low Temperature in Basrah City (South Of Iraq), International Journal of Civil Engineering and Technology, 8(6), 2017, pp. 787–796.

[20] R. Y. Tamakloe, M. Commey, Agoe Obed Nai, Turkson Samuel Kwamena and K. Singh, Effect of Porosity on OCV And West water Treatment Efficiency of A Clay Partitioned Ion-Exchange Double Chamber Microbial Fuel Cell, Volume 6, Issue 6, June (2015), Pp. 06-11. International Journal of Advanced Research in Engineering and Technology (IJARET)

[21] Saraswathy R., Saritha B., Planning of Integrated Satellite Township at Thirumazhisai, International Journal of Applied Engineering Research, v-9, i-22, pp-5558-5560, 2014.

[22] Iyappan L., Dayakar P., Identification of landslide prone zone for coonoortalukusing spatial technology, International Journal of Applied Engineering Research, v-9, i-22, pp-5724-5732, 2014.