PERFORMANCE EVALUATION OF CONSTRUCTED WETLAND

Ghulamullah Maitlo* K. C. Mukwana* S. R. Samo*

ABSTRACT

Constructed wetland is the biological wastewater treatment facility. These projects aim to treat wastewater and environmental sanitation problems through practical community based approaches. These problems confront the rapidly urbanizing cities in Asia. This is considered safe treatment and disposal method of wastewater. On the other hand conventional methods based on advanced technologies are simply not affordable or are complex to maintain in most medium and small sized towns. Constructed wetland is a complex assemblage of wastewater, substrate, and vegetation and an array of microorganisms. Vegetation has a vital role in the wetlands as it helps to serve in maintaining proper surfaces and a suitable environment for microbial growth of microorganisms and is a source of filtration. The collected samples indicate that physical, chemical and biological parameters are higher at the inlet as against NEQS. The same parameters show considerable reduction and acquire permissible levels at the outlet.

From experimental results it was derived that reduction rate of analyzed parameters such as COD, BOD, TDS, salinity, DO, TSS, nitrogen, phosphorous, Fecal coliform was effective. From the experimental work, it was found that this system is effective in reduction of pollutants from wastewater excluding dissolved oxygen. The overall removal efficiency remained up to 65%. This system reduced BOD, COD, and TDS, salinity, TSS, nitrogen, phosphorous, oil grease and fecal coliform by 94.4%, 89.5%, and 45.36%, 16.6%, 97.55%, 49.77%, 57.38%, 51.43% and 97.2% respectively. It was concluded that this treated wastewater through constructed wetlands could be used for the agriculture and aquaculture purpose.

Constructed wetlands are an effective option for on-site wastewater treatment when properly designed, installed, and maintained. Sub surface flow constructed wetlands are found to be a viable tertiary treatment alternative for municipal wastewater. These systems are potentially good, low-cost, appropriate technology treatment for domestic wastewater in rural areas where land is inexpensive.

Key words: ***Constructed wetland, substrate, permissible levels, NEQS***

1. INTRODUCTION

The chemistry of water is very interesting as it is the most abundant of all the compounds occurring in nature. It is essential to all forms of life. Apart from being essential to life, it plays a very important role in daily life. The human body is composed of 65 to 70 percent of water by weight and it is necessary to maintain most of our body functions. Water is important component of life. Earth is the only planet in the solar system to have abundant liquid water. In our homes water is used for drinking, cooking, washing and many other activities. In industry, it is used as a solvent, as a coolant and as an important chemical reagent. In agriculture, it is used for raising crops, which provide us with food and other necessities for our survival.

Grey water is that water which comes from kitchen, bathing, showers and laundry etc. Water coming from toilet is termed as black water. Many parts of the world are confronted with scarcity of water for both irrigation and human needs including Pakistan. Keeping in view the demand of water many countries have adopted to treat and recycle grey water for irrigation and other purposes. It is believed that about seventy to eighty percent water comes out from houses is grey water. Grey water treatment is simple as compared to the black water

* Department of Energy & Environment Engineering, Quaid-e-Awam University of Engineering, Science & Technology Nawabshah, Sindh, Pakistan (e-mail: mukwana_99@yahoo.com)

because black water treatment is complex and need advanced technology for treatment. Nitrogen content in black water is about ninety percent and it is very hard to extract nitrogen available in black water. Due to higher content of nitrogen makes it unfit for residential or commercial purpose (Elmitwalli and Otterpohl, 2007).

Municipal wastewater is a general term applied to liquid treated in a municipal treatment plant. Municipal wastes from towns frequently contain industrial effluents from dairies, laundries, bakeries, and factories, and those in large city may have wastes from major industries, such as chemical manufacturing, breweries, meat processing, metal processing, or paper mills. Human activity has affected the quantity and quality of water on earth. The future beneficial use of water will depend on our determination to employ new social, technical, economic, and political methods of dealing with water resources management. The reason these techniques are so necessary now is that we have reached a point in many areas where water demand exceeds the readily available supply. The opportunity of contributing to the prosperity of many millions of people by developing better management skills is an exciting challenge for those in water resources development (Cooper 1990).

Future challenges in technical aspects of water resources management are many. Our effects on fresh water over extraction and usage of freshwater resources are obvious almost all parts of the world. Fresh water over extraction is mainly for agriculture. The increasing demand of water for irrigation has significant impact on fresh water resources.

Constructed Wetland (CW) is a complex assemblage of wastewater, substrate, and vegetation and an array of microorganisms. Vegetation has a vital role in the wetlands as it helps to serve in maintaining proper surfaces and a suitable environment for microbial growth of microorganisms and is a source of filtration. Pollutants are removed within the constructed wetlands by different complex biological, chemical and physical processes.

The most commonly used hybrid system is a vertical flow (VF) followed by several stages of horizontal flow (HF) i.e. VF-HF constructed wetland which has been used for treatment of both sewage and industrial wastewaters. On the other hand, the use of a HF-VF system has been reported only for treatment of municipal sewage. Out of 60 surveyed hybrid systems, 38 have been designed to treat municipal sewage while 22 hybrid systems were designed to treat various industrial and agricultural wastewaters. The CWs with FWS units remove substantially more total nitrogen as compared to other types of hybrid constructed wetlands (Vymazal. J. 2013).

2. METHODS & MATERIALS

Constructed Wetland at village Majeed Keerio is designed, by keeping in view that the substrate of the Wetland can be rapidly filled up with debris, grit, and solids from raw wastewater, if these materials are not removed prior to the wetland through preliminary and primary treatment.

In CW at Majeed Keerio, filter beds are developed, which are actually known as a horizontal flow constructed wetlands (HFCW). These are shallow basins filled with filtering material such as rounded stone and bed is planted with different types of vegetation that has potential to survive in saturated conditions. Wastewater flows into the basin and also flows over the surface of substrate, the basin structure controls and is discharged out of the basin through a structure, which controls the depth of the wastewater in the wetland.

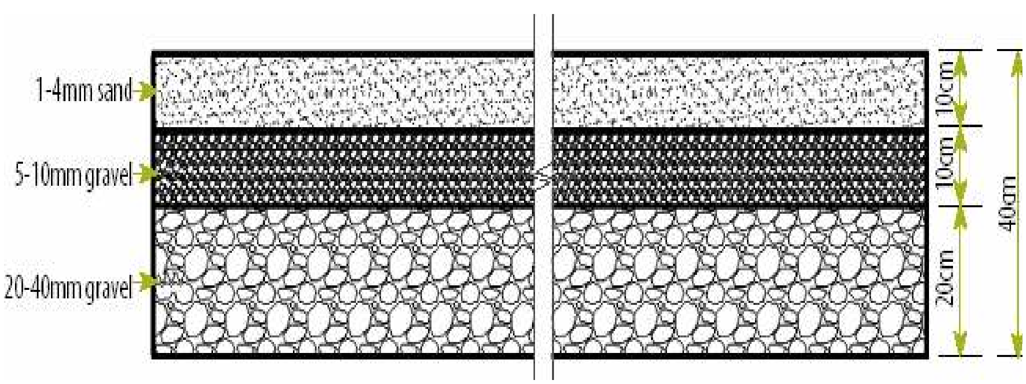

Figure 1: Sludge bed of CW Majeed Kerio.

Standard procedures and techniques used in civil engineering are applied for the basin construction of CW Majeed Keerio, which include earthwork in excavation, leveling and compaction. The importance of balancing the basin during construction cannot be under estimated. In order to protect the integrity of liner compaction of the sub grade is important during the construction of basin i.e. liner and gravel placement etc. These wetlands are graded level from side to side having a slope about 1% in the flow direction beams.

The geo membrane of 0.25mm is lined to prevent direct contact between the wastewater and groundwater. Preparation of sub grade under the liner is crucial for successful liner installation. The liner is covered with 3” RCC to cover the liner.

The cross sectional view of the constructed wetland at Majeed Kerio is shown in Fig.1. Whereas the water flow arrangements of CW at Majeed Kerio is shown in Fig. 2.

Figure 2: Water flow arrangements of CW Majeed Keerio

3. OBJECTIVES OF RESEARCH

The main objectives of this research work are as under:

1. To analyze the treatment efficiency of constructed wetland.
2. To measure the Quantity & Quality of wastewater.
3. To check the results incompliance with NEQS Pakistan.

4. QUANTITATIVE ANALYSIS

Quantification of wastewater entering in constructed wetland and discharging from it after treatment was performed. The rate of flow at inlet and outlet was measured in gallons per day at the time of collection of samples for laboratory analysis. The details of flow at inlet and outlet are shown in table 1.

Table 1: Flow of water at inlet, and outlet during sample collection

S. No	Date	Inlet (Gallons/Day)	Outlet (Gallons/Day)
1	01-01-2012	75300	74100
2	15-01-2012	74600	70200
3	29-01-2012	74950	70050
4	12-02-2012	72100	70600
5	27-02-2012	63900	60900
6	12-03-2012	56500	54030
7	26-03-2012	71000	68200

5. QUALITY ANALYSIS

Quality analysis of samples focused on following para-meters in order to compare concentration in accord-ance to permissible level in the National Environmental Quality Standards (NEQS).

a) Biochemical Oxygen Demand (BOD)

According to the National Environmental Quality Standards provided for industrial and domestic effluents biochemical oxygen demand limit is set 150mg/l. The analyzed values of biochemical oxygen demand at inlet and outlet samples of constructed wetland are presented in Fig 3.

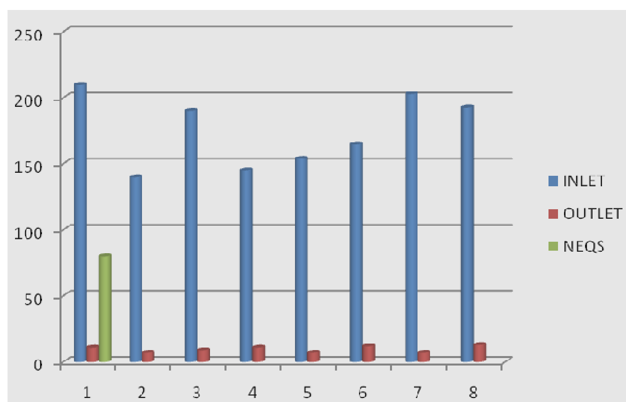

Figure 3: Graphical presentation of BOD values of CW Majeed Keerio

The obtained data shows that all values were in range of NEQS Pakistan after treatment through constructed wetland. An average value at inlet point was 104.75mg/l and at outlet it was recorded 9.625mg/l. The highest value at the inlet was recorded 125mg/l and the highest value at outlet was recorded 13mg/l respectively. The results of all samples indicate that BOD values were within NEQS limit but untreated wastewater cannot be used for irrigation purpose having high BOD level, for irrigation purpose grey water must be treated. After treatment through constructed wetland water can be reused for vegetation and irrigation purpose without causing any health hazard.

b) Chemical Oxygen Demand (COD)

According to the National Environmental Quality Standards provided for industrial and domestic effluents into sea Chemical Oxygen Demand (COD) limit is set 180mg/l. The analyzed values of chemical oxygen demand at inlet and outlet samples at constructed wetland are presented in Fig. 4. The obtained data shows that all values were in range of NEQS Pakistan after treatment through constructed wetland. An average value at inlet point was observed 782mg/l and at outlet it was recorded 110mg/l. The highest value at the inlet was recorded 910mg/l and the highest value at outlet was recorded 146mg/l respectively. COD values of constructed wetland treatment plant of Majeed Keerio before the treatment was not within the permissible limit while after the treatment of wastewater it was within the NEQS limits. Wastewater that contains high level of chemical oxygen demand poses great threat to aquatic life and is the major cause of water quality degradation.

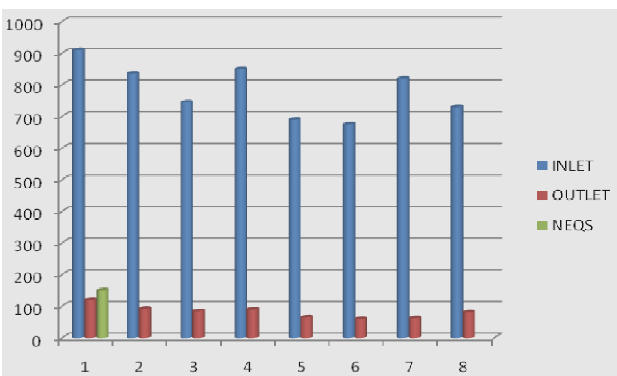

Figure 4 Graphical presentations of COD values of CW Majeed Keerio

c) Total Suspended Solids (TSS)

According to the National Environmental Quality Standards provided for industrial and domestic effluents total suspended solids limit is 200mg/l. The obtained data shows that all values were in range of NEQS Pakistan after treatment through constructed wetland. An average value at inlet point was observed 507.62mg/l and at outlet it was recorded 12.88mg/l. The highest value at the inlet was recorded 690mg/l and the highest value at outlet was recorded 35mg/l respectively. The graphical presentation of total suspended solids is given in fig. 5. The results indicate that the quantity of total suspended solids is not at higher side. It also indicates that the suspended solids are settled in sedimentation pond.

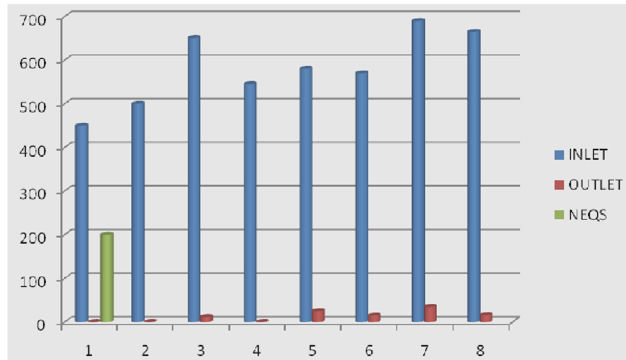

Figure 5 Graphical presentations of TSS values of CW Majeed Keerio

d) Total Dissolved Solids (TDS)

According to the National Environmental Quality Standards provided for industrial and domestic effluents total dissolved solids limit is set 3500mg/l. The analyzed values of total dissolved solids at inlet and outlet points provided for collection of samples at constructed wetland are presented in Fig.6.

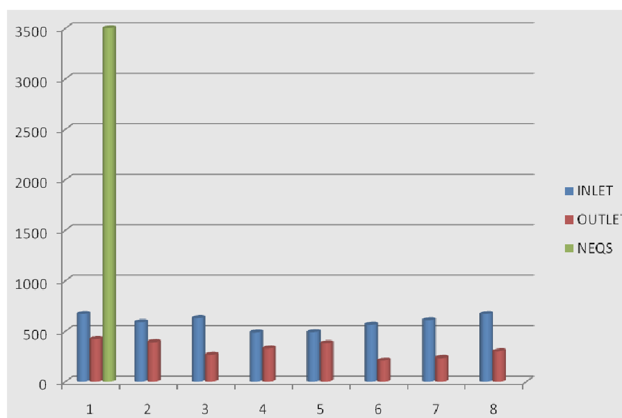

Figure 6 Graphical presentations of TDS values of CW Majeed Keerio

The obtained data shows that all values were in range of NEQS Pakistan before and after treatment through constructed wetland. An average value at inlet point was observed 589.25mg/l and at outlet it was recorded 286.62mg/l. The highest value at the inlet was recorded 670mg/l and the highest value at outlet was recorded 421mg/l respectively. The results indicate that TDS values were found incompliance to NEQS limit of

3500mg/l for all samples. As water is a universal solvent, it dissolves a wide range of substances such as calcium, magnesium, carbonate, chlorides and many other substances. Fresh water, brackish water and seawater differ primarily in their level of total dissolved solids.

e) OIL AND GREASE CONTENT

The average values of oil and grease samples collected at inlet and outlet were recorded 17.25mg/l and 8.12mg/l respectively. Permissible limit for oil and grease concentration as per NEQS for domestic and industrial effluent is 10.0mg/l. The graphical presentation of values is shown in figure 7. Improper disposal of effluent containing high levels of oil and grease can result in high biological oxygen demand (BOD) and high chemical oxygen demand (COD) levels, increased operating costs, and clogging of collection systems.

After performing analysis of oil and grease tests it was deduced that the highest value at the inlet was recorded 17.25mg/l and the highest value at outlet was recorded 8.12mg/l respectively. The results indicate that oil and grease values come under NEQS limit after treatment through constructed wetland. It shows that oil and grease was within permissible limit after treatment.

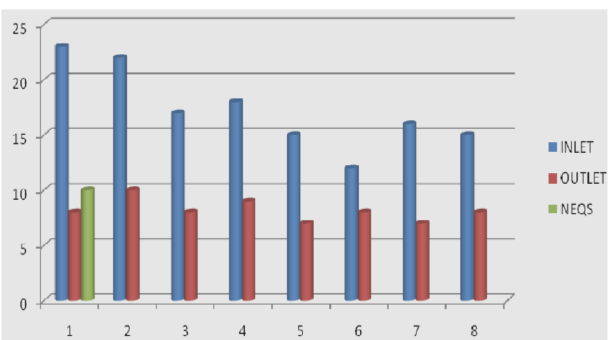

Figure 7 Graphical presentations of oil & grease values of CW Majeed keerio

6. CONCLUSION

From experimental results it was deduced that reduction rate of parameters BOD, COD, TSS, TDS and oil & grease is effective. From experimental work, it was found that this system is effective in reduction of pollutants from wastewater excluding dissolved oxygen. The overall removal efficiency remained up to 65%. This system reduced BOD, COD, TSS, TDS and oil grease by 94.4%, 89.5%, 97.55%, 45.36%, and 51.43% respectively. It is concluded that this treated wastewater through constructed wetlands could be used for the agriculture and aquaculture purpose. From experimental study, it was found that dissolved oxygen of wastewater was increased due to treatment of municipal wastewater through constructed wastewater.

7. ACKNOWLEDGEMENT

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REFERENCES

[1] Vymazal. J, "The use of hybrid constructed wetlands for wastewater treatment with special attention to nitrogen removal: a review of a recent development", Kamýcká 129, 165 21 Praha 6, Czech Republic waters 2013. Epub.

[2] Abou-Elela, S. I. and Hellal, M. S (2012), "Municipal wastewater treatment using vertical flow constructed wetlands planted with Canna, Phragmites and Cyprus", V.47, pp.209-213.

[3] Ansola, G., González, J. M., Cortijo, R., and de Luis, E. (2003), "Experimental and full–scale pilot plant constructed wetlands for municipal wastewaters treatment", Ecological Engineering, V. 21, pp. 43–52.

[4] Antoniadis, A., Takavakoglou, V., Zalidis, G., Poulios. I., (2007), "Development and evaluation of an alternative method for municipal wastewater treatment using homogeneous photo-catalysis and constructed wetlands", Catalysis Today, V. 124, pp. 260–265.

[5] Aslam M.M.; Hassan, S., and Baig M.A (2010), "Removal of metals from the refinery wastewater through vertical flow constructed wetlands", Int. Journal of Agriculture & Biology, V.12 (5), pp.796-798.

[6] Ayub, K.R.; Zakaria N.A.; Abdullah R. and Ramli, R (2010), "Water balance case study of constructed wetland as part of the bio-ecological drainage system (BIOECODS)", Water Science and Technology, V.62, pp.1931-1936.

[7] Bell, J., Melcer, H.; Monteith, H.; Asinga, I. and Steel, P. (1993), "Stripping of volatile organic compounds at full scale municipal wastewater treatment plants", Water Environment Research, V. 65 (6), pp.708-712.

[8] Cerezo, R. G, Suarez, M.L., and Vidal-Abarca, M.R (2001), "The performance of a multi-stage system of constructed wetlands for urban wastewater treatment in a semiarid region of SE Spain", Ecological Engineering, V. 16, pp. 501–517.

[9] Cooper, P. F., "Constructed wetlands in water pollution control", Conference proceedings of Constructed wetlands in water pollution control, pp. 605 year 1990.

[10] Ghermandi, A. , Bixio, D., Thoeye, C. (2007), "The role of free water surface constructed wetlands as polishing step in municipal wastewater reclamation and reuse", Science of the Total Environment, V. 380, pp. 247–258.