VOL. 6, NO. 10, OCTOBER 2011 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

ARTIFICIAL WETLANDS- AN EFFECTIVE TOOL FOR PRESERVATION OF ECO-SYSTEM OF GANGA RIVER

Dandigi M. N.[1] and Ibn Abubakar B. S. U.[2]
[1]Arba Minch University, Department of Water and Environmental Engineering, Arba Minch, Ethiopia
[2]University of Maiduguri, Department of Civil and Water Resources Engineering, Maiduguri, Borno State, Nigeria
E-Mail: bashehu@yahoo.com

ABSTRACT
This paper presents a study of an artificial wetland, at Warangal, in the state of Andhra Pradesh, India, used for the treatment of municipal wastewater. Such treatment processes are in great demand because of their satisfactory performance, low maintenance and operating costs and eco-friendliness. A free water surface type of artificial wetland was studied, with dimensions 20.0 m x 5.5 m, and a depth 0.4 m and the retention period of 7 days. Wetland vegetations consisted of emergent macrophyte Typha-latifolia. Removal efficiency of organic matter, nutrients and pathogens was observed for a period of one year. Removal efficiency of 70% COD, 65% Nitrate, 99% pathogens were achieved. The overall effluent quality was found to be acceptable for disposal into water bodies' and/or/reuse for irrigation. As the climate and typical raw wastewater quality are similar in Gangetic basin, this type of treatment may be most economical and feasible option for treating municipal and industrial wastewater in order to preserve the natural eco-system of Ganga River.

Keywords: artificial wetland, wastewater, typha latifolia, free water surface, eco-system, removal efficiency.

1. INTRODUCTION
The concern for the deteriorating quality of the environment has been increasing in recent years all over the world. In developing nations with low GDP and high population expansion, there are higher rates of environmental pollution due to poor wastewater collection, treatment and disposal systems. There is need to search for simple technology with low cost and very minimum controls. This options should replaced the conventional wastewater collection, treatment and disposal systems that requires consistent water supply, well trained skilled personals and with huge financial commitment. Biological degradation of municipal wastewater treatment has been advocated to be ecologically friendly and cost effective if apply properly (McNevin *et al*., 2000; Mitchell *et al*., 2001).

Therefore, artificially constructed wetland for treatment of tertiary wastewater is imperative; it is simple technologies, economical to install, low energy consuming and less expensive in operation and maintenance (Mashuri *et al*., 2000; Mantamoros *et al*., 2008). It has been used for treatment of storm water (Green *et al*., 1997); organic loading in municipal and industrial wastewater treatment (Hench *et al*., 2003; Yang *et al*., 2001; Vrhovsek *et al*., 1996; Yin el al., 1995; Koottatep *et al*., 2001). In addition, artificially constructed wetland has been tested on agricultural runoff, acid mines drainage (Higgins *et al*., 1993; Karanthanash and Thompson, 1995) and it was also reported to be effective for landfill leachate (Bemerd and Lauve 1995).

Consequently, a pilot plant constructed wetland system for settled (primary treated) municipal wastewater has been designed and constructed and the experimental study has been carried out on this pilot plant with the following objectives: (i) To treat wastewater and (ii) To study the improvement in the effluent wastewater quality.

2. METHODOLOGY

2.1 Study area
A pilot constructed wetland of type FWS of size 21.25m long, 5.5m wide, and 0.3m effective water depth has been constructed near the Kakatiya Musical Garden of Warangal City, an important historical city in the State of Andhra Pradesh, during December 2000, with the help of Warangal Municipal Corporation and Kakatiya Urban Development Authority (KUDA). Warangal city is situated at latitude $18^0\ 0'\ 4''$ N and $79^0\ 4'\ 28''$ East longitude. The altitude of the city is about 275m above MSL. A schematic view of the pilot wetland is shown in Figure-1 along with the sampling points.

A barrier constructed across the flow with reinforced concrete open pipes to control the flow and raise the wastewater level to the inlet level. The raising of the water level takes about 2 to 2½ hours, and allows for sedimentation to occur. The inlet channel from municipal drain was constructed with *Shahabad* stone slabs. The bottom of wetland was sealed with lean concrete to prevent infiltration. To properly fix the plants, a 60 cm thick of clay was provided as the supporting material. This clay substrate supports the emergent vegetation, *typha-latifolia.* Planting of *typha-latifolia* was done at a rate of 4 to 5 seedlings per square meter. Consequently, a fully-grown macrophytes wetland system established and system was found to be in good working condition.

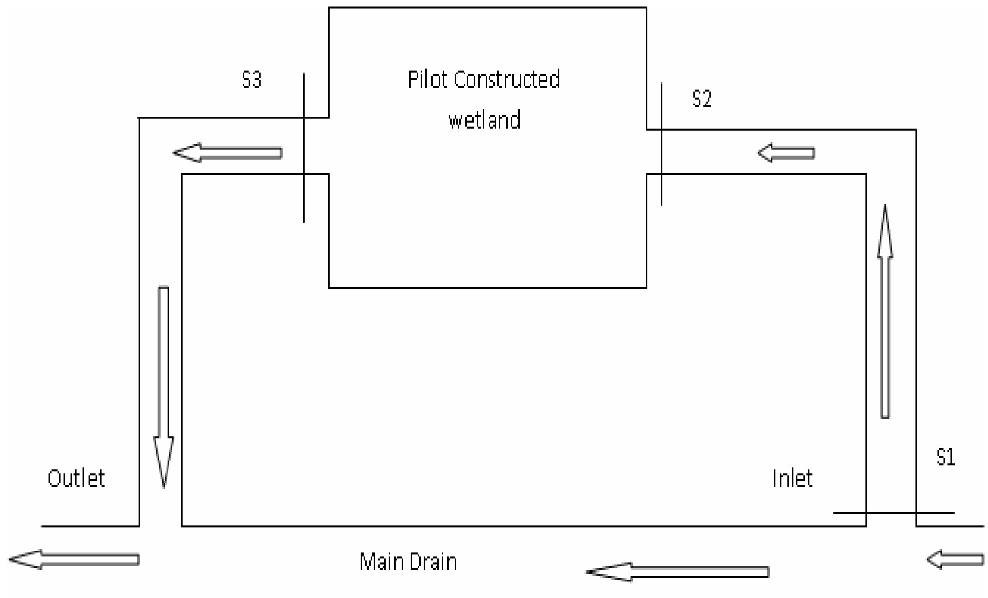

Figure-1. Schematic view of the pilot constructed wetland with a sampling station S_1, S_2, and S_3.

3. RESULTS

The ranges of values and annual average of all parameters analyzed at the inlet of constructed wetland (settled) are presented in Figure-2. It indicates clearly that even primary settlement causes significant reduction in the concentrations of the parameters analyzed/monitored at the raw sampling station.

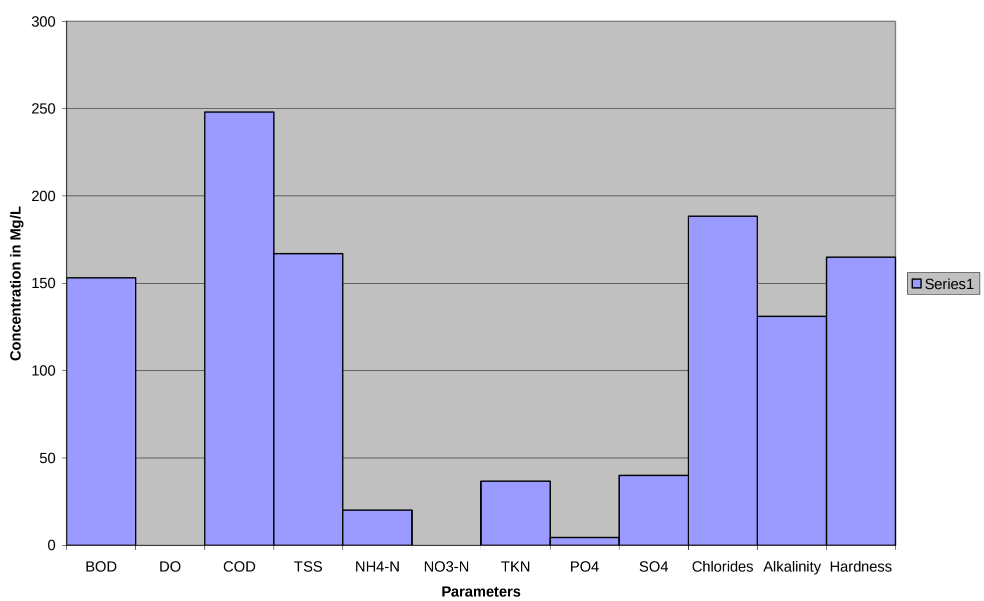

Figure-2. Annual averages values of parameters at inlet.

VOL. 6, NO. 10, OCTOBER 2011 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

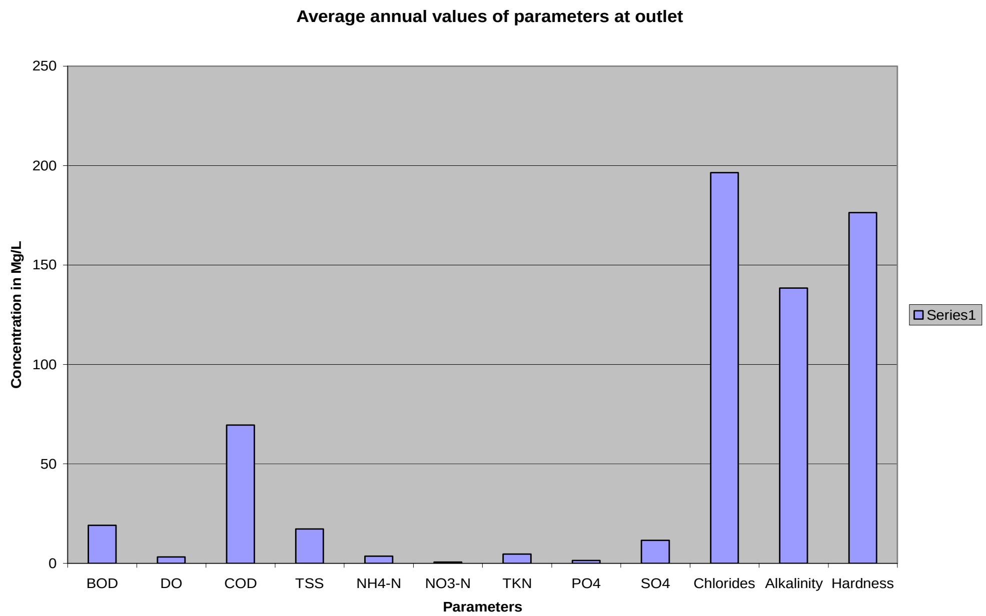

Figure-3. Annual average values of parameters at outlet.

Figure-3 above shows the characteristics of the treated effluent as it passed through the pilot wetland. The values in the Figure-3 are in general agreement with the effluent standards prescribed by the State and Central Pollution Control Boards.

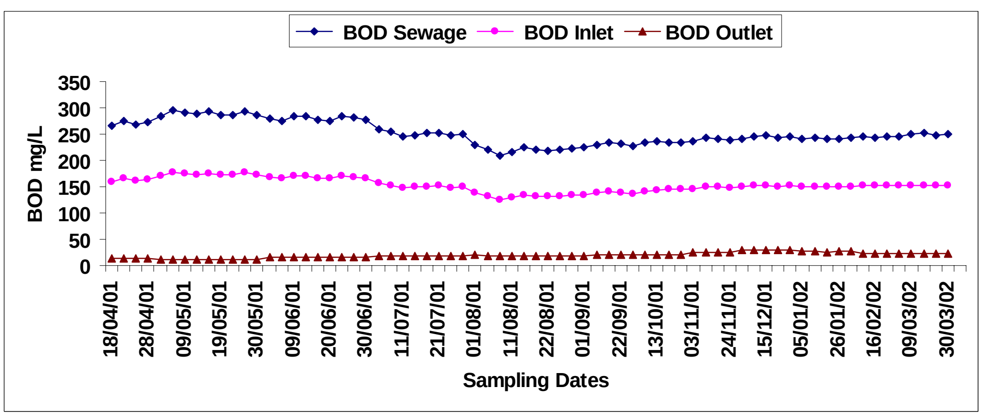

Figure-4. BOD values at raw sewage, inlet and outlet points.

Figure-4 shows the variation of BOD during different seasons at the three sampling points. It is observed that, the strength of BOD in raw and the settled sewage concentrations are quite high during the dry seasons and the concentrations are less during the rainy season, essentially because of dilution. In the treated effluent, there is a significant reduction in the concentrations of BOD. The concentrations are less during summer and more during winter seasons in the treated effluents of constructed wetland. This indicates that, the treatment efficiency is better during summer than in other seasons. Because of the bacterial growth, decomposition activities are more with temperature, and hence the concentrations are significantly less during summer months.

Kadlec and Knight (1996) proposed the k-C model for use in the analysis of treatment wetlands. When a parcel of water carrying pollutants moves from inlet to outlet, several physical, chemical and biological processes influences the water quality of the parcel; and the detailed behaviour can be very complex. But the overall effect is that the contaminant concentrations in the parcel tend to proceed by an exponential decay process towards an equilibrium value for given site at a given time. This behaviour can be described by the first order kinetic k-C^* model as given below.

VOL. 6, NO. 10, OCTOBER 2011 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

$$C_{out} = C^{*} + (C_{in} - C^{*})\, Exp(-k/q) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where

C^{*} = background concentration (mg/L)
C_{in} = input concentration (mg/L)
C_{out} = output concentration (mg/L)
k = aerial decay rate constant (m/yr)
q = hydraulic loading (m/yr)

The constructed wetland system utilizes this kinetic first order decay model to simulate the behaviour of pollutants as they pass through the constructed wetland system. This model has been used in predicting the performance of wastewater treatment through constructed wetlands (Kadlec and Knight, 1996).

The observed BOD values (experimented) at the outlet of the constructed wetland and the predicted values at the outlet by the k-C model are in close agreement with each other, except during the winter as shown in Figure-5 the performance of the constructed wetland is slightly reduced during the winter months, because of the lower temperature in winter affects microbial activities consequently low BOD removal efficiency. When the observed and predicted values are plotted against each other, as shown in Figure-6, the values scatter equally on both the sides of the 45^{0} line. The correlation coefficient between the observed and predicted values of BOD was 0.84, and in Figure-7 the efficiency of removal of pollutants verses temperature is plotted.

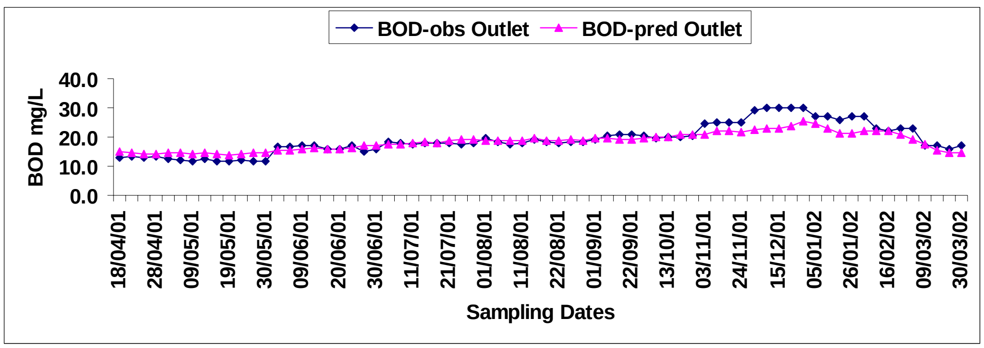

Figure-5. Variation of observed and predicted BOD at the outlet with sampling dates.

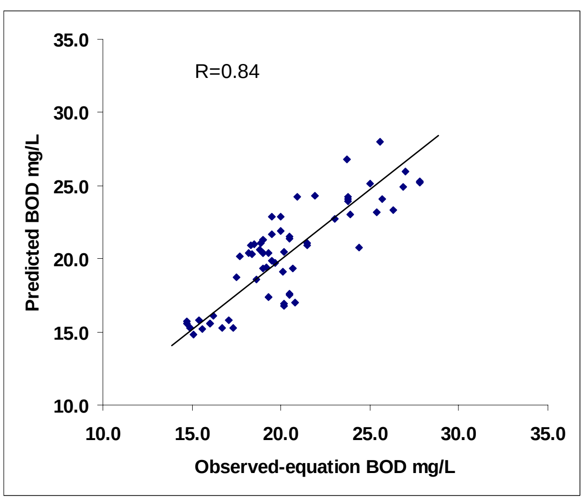

Figure-6. Correlation analysis for observed and predicted values of BOD.

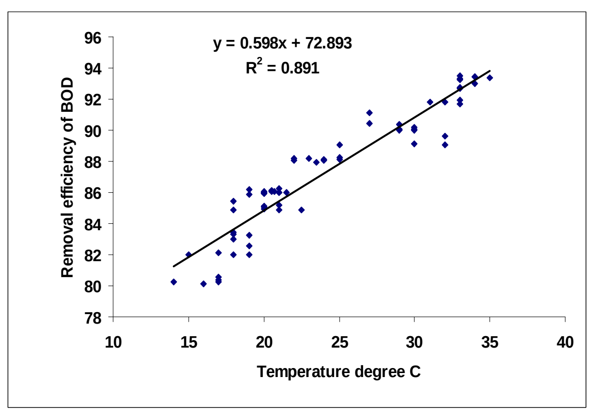

Figure-7. Regression analysis for removal efficiency of BOD with temperature.

It is found that these constructed wetland treatment systems can be very effectively applicable to remove major pollutants and the treated effluent meet the discharge standards established by the State and Central Pollution Control Boards.

4. CONCLUSIONS

The following conclusions are drawn from the knowledge and experience acquired on the functioning of surface flow constructed wetland wastewater treatment plant.

i) It is observed that various parameters analyzed had reduced concentrations as the wastewater passed through wetland system and good correlation was observed between temperature (season) and the efficiency in removal of BOD, COD, TSS, NH_4-N, TKN, PO_4, SO_4. This indicates that the performance of wetland system was much better during summer months compared to other seasons during the year. In arid and semi-arid countries, where the daily temperatures are much higher, this system of treatment of wastewater would be very effective;

ii) It can be concluded from the study that, efficient removal of both pollutants and nutrients occurs when the depth of wastewater in the wetland system is 0.3 meters. The performance is better at lower depths;

iii) The BOD, COD, NH_4-N, TKN, PO_4, SO_4 values predicted at the outlet of constructed wetland by k-C model are close to the observed values and the R(coefficient of correlation) values obtained represents that the model suits for the constructed wetland;

iv) Pathogenic bacteria removal efficiency is also good, i.e., on an average 95%, by constructed wetland system; and

v) It is observed in the study that, in the pilot plant, situated just about 4-5 meters from the main open drain carrying wastewater, the quality of the treated water was significantly better than the raw and inlet wastewater.

ACKNOWLEDGEMENTS

The authors would like to express their profound gratitude to Warangal Municipal Corporation and Kakatiya Urban Development Authority (KUDA). We also wish to express our thank to Prof. Margaret Greenway, Head, School of Environmental Engineering, Griffith University, Brisbane, Australia, for her valuable contribution and advices during this study.

REFERENCES

Bernard J.M. and Lauve T.E. 1995. A comparison of growth and nutrient uptake in phalaris arundinacea L. growing in a wetland and a constructed bed receiving landfill leachate. Wetlands. 15: 176-182.

Hench R. K., Bissonnette G.K., Sexstone A.J., Coleman J.G., Garbutt K. and Skousen J.G. 2003. Fate of physical, chemical and microbial contaminants in domestic wastewater following treatment by small constructed wetlands. Water Res. 37: 921-927.

Higgins M.J., Rock C.A., Bouchard R. and Wengrezynck B. 1993. Controlling agricultural runoff by use of constructed wetlands. In: Moshiri, G.A. (Ed). Constructed wetlands for water quality improvement. Lewis Publishers. Boca Raton Fl. pp. 359-367.

Kadlec R.H and Knight R.L. 1996. Treatment wetlands. CRC Press, New York.

Karanthanasis A.D. and Thompsom Y.L. 1995. Mineralogy of iron precipitates in a constructed acid mine drainage wetland. Soil Sci Soc. Am. J. 59: 1774-1779.

Koottatep T., Polprasert C., Koanh N.T., Heinss U., Montangero A. and Strauss M. 2001. Septage dewatering in vertical-flow constructed wetlands located in tropics. Water Sci. Technol. 44(2-3): 181-188.

Mashuari D.A., Mahuugu D.M.M. and Abdulhussein B.S. 2000. Constructed wetland at the University of Dar Es Salaam. Water Res. 34: 1135-1144.

Matamoros V., Garcia J. And Bayona J.M. 2008. Organic micro pollutant removal in a full-scale surface flow constructed wetland fed with secondary effluent. Water Res. 42: 653-660.

McNevin D., Harrison M., King, A., David and Mitchell C. 2005. Towards an integrated performance model for subsurface flow constructed wetlands. Environ Sci. Health A. 35(8): 1415-1429.

Michell C. and McNevin D. 2001. Alternative analysis of BOD removal in subsurface flow constructed wetlands employing Monod Kinetics. Water Res. 35(5): 1295-1303.

Vrhovsek D., Kukanja V. and Bulc T. 1996. Constructed wetland (CW) for industrial wastewater treatment. Water Res. 30. 2287-2292.

Yang L., Chang H.T. and Huang M., N. L. 2001. Nutrient removal in gravel and soil-based wetland microcosms with and without vegetation. Ecol. Eng. 18: 91-105.

Yin H. and Shen W. 1995. Using red beds for winter operation of wetland treatment system for wastewater. Water Sci. Technol. 3 2(3): 111-117.