International Journal of Latest Research in Science and Technology ISSN (Online):2278-5299
Vol.1,Issue 2 :Page No.60-64 , July – August 2012
https://www.mnkpublication.com/journal/ijlrst/index.php

COMPARISON OF P. *KARKA* AND V. *ZIZANIOIDES* SPECIES FOR LIVESTOCK EFFLUENT TREATMENT THROUGH VERTICAL FLOW CONSTRUCTED WETLAND

Rawal, Nidhi[1], Billore, S.K.[2], Makvana K.S.[3]
[1,2,3] School of Studies in Botany, Vikram University,Ujjain (M.P.)
*Corresponding author: email: nidhikapilp@gmail.com

Abstract – ***Constructed wetland is a natural treatment system that physical, chemical and biological processes occur when water, soil, plants and microorganisms interact. Constructed wetlands treat different types of wastewaters such as agricultural, municipal, and industrial. In this study, Vertical Flow Subsurface Constructed Wetland (VFSSCW) was applied and examined at mesocosmic level for the removal efficiency of Nitrogen and Phosphorus from livestock effluent by using sandbed as substrates planted with Phragmites karka (Reed grass) and Vetivera zizanioides (Vetiver grass).The removal of N & P within wetlands is performed generally by plant uptake and by adsorption onto sediments. VFSSCW design system was designed for retention capacity of 130 liters for about 3 days. The removal efficiency is higher in Phragmites karka compare to Vetiveria zizanioides.***

Keywords - Constructed wetland, *Phragmites karka, Vetiveria zizanioides,* Livestock effluent.

INTRODUCTION

Globally water is becoming gradually a scarce resources. In India alone the International Water Management Institute (IWMI) predicts that by 2025, one person in three will live in conditions of absolute water scarcity (IWMI,2003). India occupies only 3.29 million km^2 geographical area, which forms 2.4% of the world's area, it supports over 16 percent of world's population, but has only 4% of the total available fresh water. This clearly indicates the need for water resources development, conservation and their optimum use (Billore *et al.*, 2009). A new report from FAO says livestock production is one of the major causes of the world's most pressing environmental problems, including global warming, land degradation, air and water pollution, and loss of biodiversity. The concerns over environmental effects of livestock production in India are of relatively recent origin. It is generally considered that the environmental impacts of livestock production in India have more positive implications than negative ones as the production system is still largely predominated by rural based crop livestock integrated smallholder mixed farming system (Chacko *et.al.*,2006). Livestock farms close to population centers and watercourses produce ecological harm due to over concentration of nutrients and human health issues. The same thing will happen in rural units as well if the wastes are not properly handled/managed.

The conventional wastewater treatment processes are expensive and require complex operations and maintenance (CPCB, 2005a). The waste water treatment technologies are shifting towards bio-eco-engineering technologies, which are a new field in the science of ecology and can be viewed as designing or restoring ecosystems according to ecological principles can be termed as Eco-technology(Billore *et al.*,2009). The heavy pollution load emanating from variety of urban, industrial and agricultural activities which meets water bodies through point and non-point sources, are the major cause of apathetic condition of water system.

Constructed wetland have been shown to provide an alternative system for wastewater treatment that requires lower capital and maintenance costs, and generally, no or very little energy to operate it (Reddy and Gale, 1994). The Constructed Wetlands (CWs) are characterized by plantation of wetland vegetation, *Phragmites* species is the most commonly used wetland species in most of the studies. However, the individual species may have different potential for nutrient removal depending upon its uptake, growth pattern, size of supporting bed material, oxygenation ability, nature of wastewater and season. (Browning and Greenway 2003). We selected local available plant species – *Phragmites karka* and *Vetiveria zizanioides* as wetland vegetation.

Constructed wetland system has proved to be well suited for treating variety of wastewater in urban, suburban and rural areas of European countries. On the contrary, only few CWs are installed to study potential applicability of this technology in India till date (Sonavane *et al*.,2008). VFSSCW have been used successfully in different countries for various wastewater treatments (Prochaska *et al.*, 2007, Brix and Arias, 2005, Tsihrintzis *et al.*, 2007).

The objective of the present study were to assess the ability of vertical flow constructed wetland systems to treat livestock effluent to evaluate the performance of system planted with *P. karka* and *V. zizanioides*.

Publication History
Manuscript Received : 10 July 2012
Manuscript Accepted : 2 August 2012
Revision Received : 15 August 2012
Manuscript Published : 31 August 2012

MATERIAL AND METHODS

Site description:

for the present study, the fabricated mesocosm system was installed in school of Studies in Botany, Ujjain(23.12' N latitude, 75.42'E longitude, mean sea level 515.45m) located in the central part of Madhya Pradesh state, India.

Collection and system design:

Livestock effluent was collected from different cattleshed in Ujjain and placed in a plastic container. The raw livestock effluent has not been used in constructed wetland. Therefore the low concentration of livestock effluent was used to enhance the success of selection of plant species.

For mesocosm specifically designed RCC tank was fabricated for the construction of vertical flow subsurface constructed wetland (VFSSCW). The vertical flow treatment (size: Length – 1.72m, Width – 0.65m., Depth-0.60m., Effective surface Area – 1.118m^2, total volume – 67.08m^3) was built with cement and iron. It was a waterproof structure. The treatment unit consists of two treatment system combine in series. One after another with identical dimension.

Filter media:

A mixture of fine and coarse Kshipra river sand was taken as filter media which provides anchorage to key macrophytes. The Kshipra river sand washed thoroughly with tap water in order to remove the dirt and other impurities. The washed river sand sieved to get sand of uniform nature/size.

The filter media was then overlaid upto a depth of 35cm. From the bottom of enclosure tanks. The filter media meets following standard porosity – 35% effective grain size> 0.05cm.

Wetland Vegetation:

The plant species *Phragmites karka* Trin., (Reed) *Vetiveria zizanioides* L. (Vetiver) were selected as a wetland vegetation and planted in filter media of separate enclosure tank to enhance the treatment efficiency of the system constructed for treatment of livestock effluent. The Reed Bed and Vetiver Bed Treatment Systems consisted connected of two enclosure tank connected in series. Reed and Vetiver were planted over the surface area of 1.118m^2 with the plant density 06-10 plant/m^2 and 12 plant/m^2 respectively. VFSSCW design system was designed for retention capacity of 130 liters for about 3 days. Samples were collected from different sampling points. First sampling point was inlet where livestock effluent went for treatment; second sampling point was final outlet respectively. Samples have been taken monthly to observe and analyze the different monthly effect.

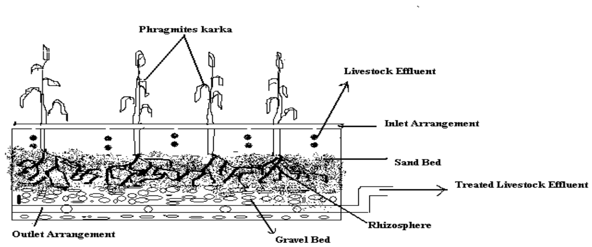

Figure 1: Cross Sectional View of Vertical Flow Subsurface Constructed Wetland (VFSSCW)

Ammonium- N and Nitrate-N were estimated by steam distillation method and Total Nitrogen was estimated as Total Kjeldahl Nitrogen (TKN) by steam distillation method (Bremner and Keeney, 1965). Vanadomolybadic Acid Colorimetric method was used for the total Phosphorus estimation in the treated and untreated livestock effluent samples.

RESULT AND DISCUSSION

For the present study, the fabricated mesocosm system was installed in campus of School of Study in Botany which is situated at Ujjain. Results are shown in below tables.

Table1:Monthly results of Ammonium – N (mg/l) in untreated (Inlet) and treated livestock effluent (Outlet) by Vertical Flow Constructed Wetland, using of *Phragmites karka* and *Vetiveria zizanioides* (From January 2008 to December 2008).

Month	Inlet	*Phragmites karka*		*Vetiveria zizanioides*	
		Outlet	% Reduction	Outlet	% Reduction
Jan	74.7	18.9	74.75	22.7	69.62
Feb	76.1	18.8	75.33	21.2	72.17
Mar	78	13.4	82.79	19	75.61
Apr	83.7	11.7	86.06	15.7	81.24
May	87.3	11.6	86.67	15.7	82.05
Jun	86.9	8.9	89.72	14.1	83.81
July	69.4	22.7	67.24	26.6	61.72
Aug	70.9	23.3	67.12	26.3	62.84
Sep	69.9	22	68.46	24.3	65.22
Oct	72.1	20.5	71.57	22.7	68.47
Nov	72.8	19.9	72.62	22.3	69.43
Dec	74.3	17.9	75.87	21.9	70.49
Avg.	76.3	17.3	77.34	21.04	72.43

The 76.3mg/l average value of $NH4^+$ - N in inlet point for VFSSCW of Possesing *Phragmites karka* and *Vetivera zizanioides* were analysed in livestock effluent. After the treatment the average values of $NH4^+$ - N 17.3mg/l, and 21.04mg/l were recorded by *Phragmites karka* and *Vetivera zizaniodies* respectively. Reduction in the NH_4^+ - N in outlet treated waters of the system indicates that many aerobic and anaerobic chemical processes are going in vegetation beds properly.

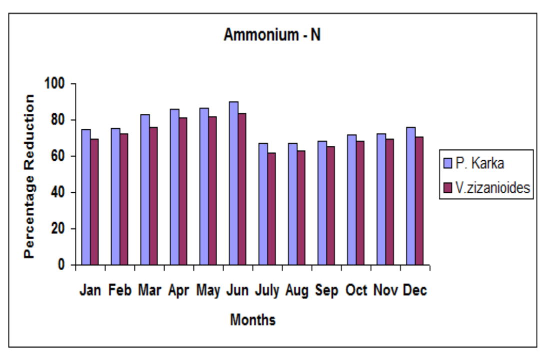

Fig.1: Comparative monthly percentage reduction results of Ammonium – N (mg/l) in untreated (Inlet) and treated livestock effluent (Outlet) by Vertical Flow Constructed Wetland, using of *Phragmites karka* and *Vetiveria zizanioides* (From January 2008 to December 2008).

Table2: Monthly results of Nitrate – N (mg/l) in untreated (Inlet) and treated livestock effluent (Outlet) by Vertical Flow Constructed Wetland, using of *Phragmites karka* and *Vetiveria zizanioides* (From January 2008 to December 2008).

Month	Inlet	*Phragmites karka*		*Vetiveria zizanioides*	
		Outlet	% Reduction	Outlet	% Reduction
Jan	11.87	3.53	70.22	4.63	60.97
Feb	13.13	3.45	69.92	4.83	63.19
Mar	15.97	4.50	71.82	5.47	65.77
Apr	16.93	4.33	74.41	6.07	64.17
May	18.63	4.27	77.10	5.80	68.87
Jun	16.80	3.60	78.57	5.73	65.87
July	11.27	4.53	59.76	5.57	50.61
Aug	13.10	5.33	59.26	6	54.20
Sep	14.37	5.40	62.41	6.47	55.00
Oct	15.33	5.47	64.35	6.63	56.73
Nov	13.00	3.73	71.28	5.07	61.03
Dec	12.97	3.73	71.21	4.97	61.71
Avg.	14.45	4.38	69.69	5.60	61.23

Highest NO_3^- –N percentage reduction occurred in June Month 78.57 by Reed bed while percentage reduction by Vetiver bed highest in May month. This is occurred due to anaerobic conditions occurred in vegetation beds.

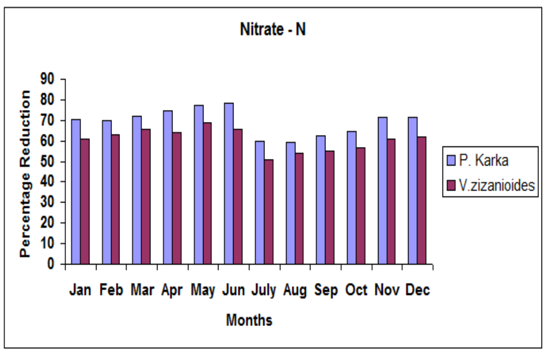

Fig.2: Comparative monthly percentage reduction results of Nitrate – N (mg/l) in untreated (Inlet) and treated livestock effluent (Outlet) by Vertical Flow Constructed Wetland, using of *Phragmites karka* and *Vetiveria zizanioides* (From January 2008 to December 2008).

Table3: Monthly results of TKN in untreated (Inlet) and treated livestock effluent (Outlet) by Vertical Flow Constructed Wetland, using of *Phragmites karka* and *Vetiveria zizanioides* (From January 2008 to December 2008).

Month	Inlet	*Phragmites karka*		*Vetiveria zizanioides*	
		Outlet	% Reduction	Outlet	% Reduction
Jan	180.7	36.0	80	46.9	74.05
Feb	181.4	30.6	83.1	42.9	76.33
Mar	183.4	24.7	86.5	37.2	79.72
Apr	125.9	21.9	82.5	32	74.52
May	184.1	20.1	89	31.2	83.07
Jun	182.1	15.5	91.4	25.9	85.73
July	154.7	49.3	68.1	57.8	62.61
Aug	160.3	42.9	73.2	52.4	67.32
Sep	166.9	37.1	77.7	46.1	72.36
Oct	175.8	34.7	80.2	44.7	74.54
Nov	180.1	29.8	83.4	38.1	78.84
Dec	179.8	28.7	84	40.3	77.55
Avg.	171.28	30.99	81.9	41.32	75.88

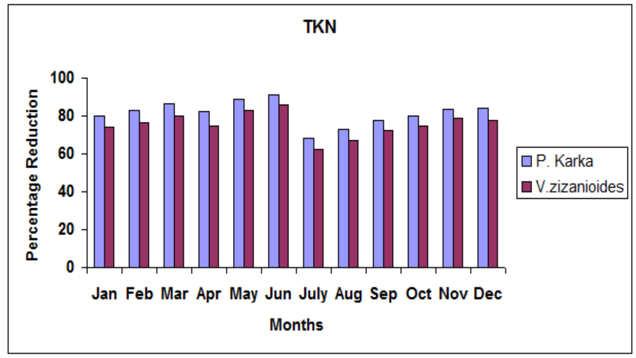

Fig.3: Comparative monthly percentage reduction results of TKN (mg/l) in untreated (Inlet) and treated livestock effluent (Outlet) by Vertical Flow Constructed Wetland, using of *Phragmites karka* and *Vetiveria zizanioides* (From January 2008 to December 2008).

The minimum and maximum values of TKN in livestock effluent is from 125.9mg/l to 184.1mg/l observed during the one year study. 81.9% and 75.88% decreases in TKN after the treatment through these VFSSCW systems of Reed bed and Vetiver bed respectively. These significant reduction in TKN value are considered due to many ongoing biological processes like aerobic and anaerobic denitrification, plant uptakes, volatilization and biofilm immobilization .

Table4: Monthly results of Total Phosphorus (mg/l) in untreated (Inlet) and treated livestock effluent (Outlet) by Vertical Flow Constructed Wetland, using of *Phragmites karka* and *Vetiveria zizanioides* (From January 2008 to December 2008).

Month	Inlet	*Phragmites karka*		*Vetiveria zizanioides*	
		Outlet	% Reduction	Outlet	% Reduction
Jan	73.9	29.56	60.00	30.20	59.13
Feb	78.3	32.17	58.91	32.87	58.01
Mar	80.2	33.82	57.82	34.92	56.45
Apr	82.4	32.15	60.98	32.03	61.12
May	83.1	26.75	67.80	26.58	68.01
Jun	85.00	28.96	65.92	29.85	64.88
July	67.1	40.26	40.00	40.54	39.57
Aug	69.05	37.74	45.34	39.21	43.21
Sep	68.0	39.26	42.26	40.37	40.62
Oct	70.6	30.22	57.19	30.59	56.66
Nov	73.2	28.01	61.73	29.24	60.05
Dec	75.4	28.57	62.10	29.73	60.57
Avg.	75.52	32.29	56.67	33.01	55.69

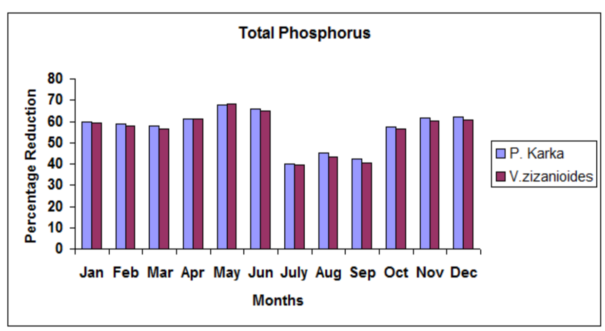

Fig.4: Comparative monthly percentage reduction results of Total Phosphorus (mg/l) in untreated (Inlet) and treated livestock effluent (Outlet) by Vertical Flow Constructed

Wetland, using of *Phragmites karka* and *Vetiveria zizanioides* (From January 2008 to December 2008).

The range of the Total Phosphorus in untreated livestock effluent 67.1 to 85.00 mg/l was analyzed. By the VFSSCW of the reed bed the average value of phosphorus 75.52mg/l was recorded in inlet and in outlet point 32.29mg/l was observed. The highest reduction occurred during May month by Reed bed and lowest by Vetiver bed during July month.

Within the wetland system, most nutrients undergo a variety of transformations that result in their removal or reduction in the outflow. Plants abet and assist in these transformations in various ways but the transformation pathways of N and P differ considerably. Physical, chemical and biological factors influence the nitrogen removal both spatially and seasonally and the nitrogen removal efficiency varies among wetlands and throughout the year. Nitrogen transformation within the wetland systems follows several paths of which nitrification-denitrification plays a major role under aerobic-anaerobic conditions. Many studies have reported denitrification as the major pathway for N removal in the emergent macrophyte based treatment wetlands (Howard,1985). Plants can normally utilize only NO_3^- - N for uptake, and therefore, the near total removal of NH_4^+- N from the wastewater cannot be attributed to plant uptake. Nitrogen elimination in wetland begins with microbial ammonification of organic bound nitrogen, which can be either aerobic or anaerobic (Hiley,1995). In a vertical subsurface flow constructed wetland (as in the present study) usually prevails aerobic condition in the water layer just below the surface while anaerobic condition prevails in the deeper zone within the bed. Nitrification or oxidation of ammonia to nitrate is an oxygen demanding process and occurs in two steps involving microbial species such as Nitrosomonas and Nitrobactor. The decrease in quantity of NH_4^+ from influent can be attributed to high microbial ammonification and nitrification within each treatment cell. Further due to the release of H^+ during microbial nitrification processes, reduction of pH in the wetlands supports high nitrification activity. There is growing evidence that NH_4 can be lost by anammox process (anaerobic ammonia oxidation) (Jetten et al., 2004; Reginatto *et al*., 2005). Under anaerobic condition anammox process appears to dominate for significant removal of ammonia nitrogen. Phosphorus is typically present in wastewater as orthophosphate, dehydrated orthophosphate (polyphosphate) and organic phosphorus. Biological oxidation results in the conversion of most phosphorus to the orthophosphate forms (Cooper *et al*.,1996). Phosphorus removal in wetland treatment systems occurs from adsorption, plant absorption, complexation and precipitation (Watson *et al*., 1989). Thus, the present study is in support of earlier work of Knight *et al*.,1993 and Billore, *et al.*,2008. Differences in percent removal in nitrogen species can be explained by the residence time in the cell, aerobic- anaerobic controlled nitrification-denitrification pulse (Reddy, *et al.*,1989), plant uptake, volatilization (Billore, *et al.*,1994), or biofilm immobilization. The surface temperature of the filter media in each cell reaching 56-62°C during the summer season (March to mid June) significantly enhances ammonia removal through volatilization (Billore, *et al.,* 2001). Similar results have also been obtained in the present study. Constructed wetlands are man-made complex of saturated substrates, emergent and sub-emergent vegetation and water, which simulate natural wetlands for human benefit (Hammer,1989). Constructed wetlands (CWs) are vigorous biological systems that can be applied for the treatment of several types of polluted water (Brix, 1994; Vymazal *et al*.,2006).

CONCLUSION

Constructed Wetlands are considered the most promising technology for the treatment of diffirent types of wastewater due to low cost simple operation and maintenance and favourable appearance. Vegetation play an integral role in wetland treatment system by transferring oxygen through their roots to the bottom of treatment basins and by providing a medium beneath the water surface for the attachment of microorganism that perform the biological treatment. The treatment performance of Vertical Subsurface Flow Construted Wetland (VFSSCW) revealed that this low cost and nature based ecotechnology can generate avoidance of nutrient pollution from the livestock effluent at the receiving end. The VFSSCW system has been proven to be an effective system which utilizes the interaction of emergent plant, microorganisms and media in the removal of pollutant. Reedbed VFSSCW system made up of *Phragmites karka* was efficiently treat livestock effluent compare to *Vetiveria zizanioides*. The overall study recommends the use of VFSSCW systems for the treatment of livestock effluent for the nutrient removal.

REFERENCES

[1] **Billore, S.K.,** Dass, P., Vyas, H., 1994. Ammonia volatilization through plant species in domestic wastewater applied to agriculture field and wetland. In : Proceedings of the 4th International Conference on wetland systems for water pollution control, Guangzhou, 171-179.

[2] **Billore, S.K.,** Singh, N., Ram, H.K., Sharma, J.K., Singh, V.P., Nelson, R.M., Dass, P. 2001. Treatment of Molasses based distillery effluent in a constructed wetland in Central India. Wat. Sci. Tech. 44, 441-448.

[3] **Billore, S. K**., Prashant, Sharma, J.K., Singh, N., Ram, H.K., Dass, P., Jain, R. 2008. Restoration and conservation of stagnant water bodies by gravel-bed treatment wetlands and artificial floating reedbeds in tropical India. In proceedings of a International Conference on Wetland systems technology in water pollution control, International water association, Indore, India, 01-07 November. 408-414.

[4] **Billore, S.K**., Sharma, J.K. and Makvana, K.S. 2009. Land based and floating reedbed eco-techniques for waste water management in India. In Proceedings of Ist IWA Development Congress on water and sanitation services from 15-19 November 2009 at Sheraton Centro Historico, Mexicocity, Mexico.

[5] **Bremner H.** and Keeney. 1965. Steam distillation method for estimation of ammonia, nitrate and nitrite. Anal. Chem. Acta., 32, 485-582.

[6] **Brix, H.** 1994. Wastewater treatment in constructed wetlands: system design, removal process, and treatment performance. In: Constructed wetlands for water quality improvement. Ed. Moshiri, G.A., Lewis Pub., New York. 9-22.

[7] **Brix, H.,** Arias, C.A. 2005. The use of vertical flow constructed wetlands for onsite treatment of domestic wastewater : New Danish Guidelines. Ecol. Eng. 25, 491- 500.

[8] **Browning, K.** and Greenway, M. 2003. Nutrient removal and plant biomass in a subsurface flow constructed wetland in Brisbane, Australia, Wat. Sci. Tech., 48(5), 183-189.

[9] **Chacko, C. T.,** Gopikrishna, Padmakumar, V., Sheilendra, T. and Vidya Ramesh. 2006. Livestock in the changing landscape in India; its environmental, social and health consequences and responses – A case study. New Delhi.

[10] **Cooper, P.A.,** Job, G.D., Green, M.B., Shutes, E.B.E. (Eds.). 1996. Reed Beds and Constructed Wetlands for Wastewater Treatment. WRc Publications, Swidon, UK.

[11] **CPCB.2005a.** Parivesh sewage pollution – News letter. Central Pollution control board, Ministry of Environment and Forest, Govt. of India Parivesh Bhavan, East Arjun Nagar, Dehli – 110032.

[12] **Hammer, D.** 1989. Constructed wetlands for wastewater treatment: Municipal, Industrial, and Agricultural. Lewis Publishers, Chelsea.

[13] **Hiley, P.D.** 1995. The reality of sewage treatment using wetland. Wat. Sci. Tech., 32, 329-338.

[14] **Howard- Williams, C.** 1985. Cycling and retention of nitrogen and phosphorus in wetlands: A theoretical and applied perspective. Freshwater Biology, 15, 391- 431.

[15] **International Water Management Institute (IWMI)** Annual Report 2002-2003. 2003 Colombo, Shrilanka.

[16] **Jetten, M.S.M.,** Cirpus, I., Kartal, B., van niftrik, L., van de Pas – Schoonen, K. T., Sliekers, O., Haaijer, S., van der Star, W., Schmid, M.,van de Vossenberg, J.,Schmid, I., Harhangi, H., van Loosdrecht, M., Kuenen, J., Op den Camp. H., Strous, M. 2004. 1994-2004:10 years of research on the anaerobic oxidation of ammonium. 10th Nitrogen Cycle Meeting.

[17] **Knight, R. L.,** Ruble, R.W., Kadlec, R.H., Reed, S. 1993. Wetlands for wastewater treatment: Performance database. In: G. Moshiri(Ed.), Constructed wetland for water quality improvement, CRC Press, Boca Raton, FL.

[18] **Prochaska, C.A.,** Zouboulis, A.I., Eskridge, K.M. 2007. Performance of pilot – scale vertical flow constructed wetlands, as affected by season, substrate, hydraulic load and frequency of application of simulated urban sewage. Ecol. Eng., 31,57-66.

[19] **Reddy, K. R.,** Patrick, W. H., Lindau, C. W. 1989. Nitrification-denitrification at the plant root- sediment interface in wetlands. Limnol. Oceanogr., 34, 1004- 13.

[20] **Reddy, K.R**., Gale, P.M. 1994. Wetland process and water quality: a symposium overview. J.Environ, Qual. 23,875-877.

[21] **Reginatto, V.,** Teixeira, R.M., Pereira, F., Schmidell, W., Furigo Jr, A., Menes, R., Etchebehere, C., Soares, H.M. 2005. Anaerobic Ammonium oxidation in a bioreactor treating slaughterhouse wastewater. Brazilian J. Chem. Eng., 22, 593 – 600.

[22] **Sonavane, P.G.,** Munavalli, G.R., Ranade, S.V. 2008. The Nutrient removal by root zone treatment. J. Environ. Sci. Engg., 50 (3), 241 – 248.

[23] **Tsibrintzis, V. A.,** Akratos, C. S., Gikas, G. D., Karamouzis, D., Angelakis, A. N. 2007 Performance and cost comparison of a FWS and a VSF constructed wetland systems, Environ. Tech., 28 (6), 621 – 628.

[24] **Vymazal, J.,** Greenway, M., Tonderski, K., Brix. H., Mander, U. 2006. Constructed wetlands for wastewater treatment. In: Verhoeven, J. T. A., Beltman, B. Bobbink, R., Whigham, D. F. (Eds.), Wetlands and natural resource management. Ecol. Studies, Springer. Verlag, Berlin Heidelberg, 190, 69 – 96.

[25] **Watson, J.J.,** Reed, S.C., Kadlec, R.H., Knight, R.C., Whitehouse, A.E. 1989. Performance expectations and loading rates for constructed wetlands. In Hammer, D.A. (Ed.) Constructed wetlands for wastewater treatment. Lewis Publishers, Chelsea, MI. 319-351.