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Efficacy of Rootzone Technology for Treatment of Domestic Wastewater: Field Scale Study of a Pilot Project in Bhopal. (MP), India.

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ABSTRACT

The urban water bodies in tropical developing countries are the worst victim of domestic wastewater / sewage, basically because of the widening gap between the increasing waste water generation and unavailability of commensurating economical resources to address the issue through conventional technologies. Hence, biological machines may prove to be a novel tool for sustainable management of water bodies. Rootzone technology being natural biological systems operating solely on solar energy is low cost and almost negligible operation and maintenance.

The paper under reference therefore is an attempt to evaluate the performance efficiency of a field scale *Horizontal Subsurface Flow constructed Wetland/Rootzone* demonstration unit was constructed by Environmental Planning & Coordination Organisation (EPCO) at Ekant Park, Bhopal as an economically and ecologically viable pilot project. The unit is designed to treat

70,000 liters/day of wastewater of nalla passing through the park. The unit comprises of pretreatment (settling tank – 35 m$^{3)}$ followed by Rootzone bed (700 sq.m) with gravels, Reed plants (*Phragmitis karka)* and inlet-outlet arrangements for sub-surface flow. To study the performance efficiency of the system physical-chemical and biological parameters of inflow and outflow water were monitored. Standard methods by APHA 1989 were followed for analysis.

The average treatment performances were recorded monthly for 18 months after its installation (April 2002 to Sep 2003). The pollution removal efficiency of the system gradually increased and as the system stabilized to a large extent after 18 months the results clearly indicated removal efficiency of 100% for Organic Nitrogen, 98.7% for Coliform bacteria, 88.4% for Turbidity, 79.0% for TSS, 70.7 % for Total Solids, 71.2 % for TDS, 77.8 % for COD, 8.9% for TKN, 65.7% for BOD, 62 % for Nitrate Nitrogen, 53.3% for Ammonium Nitrogen. The treated water/ effluent's D.O. levels increased by 139 % and reached 3.1 mg/l. indicating existence of aerobic conditions in the Rootzone bed.

The treated water can be used safely for purposes like irrigation, aesthetic ponding, fish farming, washings, biodiversity etc. Results established that the overall removal efficiency of the system studied ranged from 65% to 90 % for various pollutants, besides being cost effective treatment technology.

Keywords: Constructed wetland, Horizontal Sub Surface Flow (HSSF) system, pretreatment, gravel bed, Phragmites karka, , aerobic, nutrients, rhizospheres.

INTRODUCTION

The urban water bodies in tropical countries are under severe threat both quantitatively as well as qualitatively. Majority of them are eutrophicated with nutrient load. They are the worst victims of increased urbanization, domestic waste water/sewage and municipal waste, basically because of widening gap between the increasing wastewater generation and unavailability of commensuration economical resources to address the issue through conventional technologies. Hence Biological machines like Root zone technology (constructed wetlands) may prove to be a novel tool for sustainable management of water bodies. These systems have certain advantages as compared to conventional systems. Root zone systems operate solely on solar energy hence are low cost, operation and maintenance free technology. The ability of Root zone systems to assimilate nutrients is considered a beneficial attribute in treating wastewater. Interest in implementation of this technology around the world has accelerated over the past few decades (Knight et.al 1991, Kadlec 1993, 1996, Wood 1995, Cooper et.al. 1996). Use of constructed wetlands (CWs) is now recognized as an accepted low cost technology especially beneficial to small towns and communities that cannot afford expensive conventional treatment systems (Reddy and Gale 1994, Billore et.al 1998,& 2002). The sub-surface flow (SSF) wetlands have received popularity when compared to free water

surface (FWS) system due to decreased risk of nuisance from flies, odour and great efficiency in terms of usage (Reed et.al, 1995 ,Wood 1995).However, the system is still at pilot stage in developing countries. Presently very little efforts have been done in developing countries for treating the municipal wastewater through constructed wetlands on community level field scale. However, few scattered studies on pilot scales have been done in India as well. Some scientists have evaluated treatment of municipal wastewater and distillery wastewater and related to some aspects in India recently. (Reddy et,al 1989, Billore et.al 2000, Singh 2000, Billore et.al 2002). Rangaswami & Subramanium, 2002 studied the treatment of wastewater for small and medium sized communities using root zone bed in Mahendragiri, Tirunavelli district , Tamil Nadu. Central Pollution Control Board (CPCB) in collaboration with GTZ, Germany has undertaken pilot study on Root Zone Treatment System for treatment of dairy effluent at Mother Dairy, Delhi. The dairy wastewater, with average BOD of 800 mg/1 and BOD range from 8000 mg/l to 12000 mg/l was used for the experiment.

The present study is an attempt to evaluate the performance efficiency of field scale horizontal subsurface flow (HSSF) constructed wetland [CW] root zone method for treatment of domestic wastewater (sewage) with objective to expand the pilot stage to field level application . These investigations were encompassed in a project entitled *"Root Zone Technology for treatment and reuse of domestic wastewater"* conducted by Environmental Planning and Coordination Organization (EPCO) and Capital Project Administration under the Housing and Environment department of Government of MP . in collaboration with Institute of Environment Management and Plant Sciences, Vikram University, Ujjain – MP. The treated water was used for irrigating the plants and lawns in the park.

METHODS

Study Site

A field scale unit of Rootzone system was established at Guru Govind Singh Park (Ekant Park) in the southern area of Bhopal town (77°35' E longitude 23°25' N latitude, 460-525 m above mean sea level) in the state of Madhya Pradesh, central India. The climate of the area is characterized with summer ,monsoon, post-monsoon and winter seasons/ About 95% of the rainfall occurs during monsoon (mid June to mid September) and normal annual average rainfall ranges between 637mm to 1673 mm. The average minimum temperature during winter varies between 7° C to14° C

. During summer season (March to mid June) the maximum temperature goes upto 45 ° C.

Establishment of Root zone (Constructed wetland) System Unit

Type: – Horizontal Sub Surface Flow (HSSF) with Reed bed. The water level is maintained below the top of the soil surface unlike in free water surface system (FWS) in which waterline is exposed.

Wastewater inflow: - An earthen nalla flows through the Ekant Park. It carries domestic wastewater from the adjoining residential area (part of Char Imli colony area). This nalla joins the main nalla flowing from behind (west side) the park. A simple diversion was made to provide controlled inflow of 70,000 litres /day of wastewater to the Root zone system.

Pretreatment:-The wastewater flowing through the nalla contains silt/sediments, floating suspended materials (polythene pouches, leaves wood pieces etc.) To remove the floating material and other debris. Gabion structures (3 No.) were constructed in the upstream across the nalla. Prior to entry in the root zone system the wastewater is pretreated in settling tank of 35.0 m^3 capacity with retention time of eight hours. This chamber provides settling of settleable solids presents in the wastewater. The overflow wastewater is then passed through filter medium consisting of brick pieces and boulder stones (5-12 cm diameter). This pretreatment help in removing the floating materials and sediments to large extent from the wastewater before entering the rootzone system.

Rootzone or Main Reed Bed

A. Gravel bed: - The root zone bed was constructed in the month of April 2002 in an area of 700 sq.m having depth 0.70 m , approximate length breadth ratio 2:1 , 1% slope and water retention time of 2.6 days. The bottom of bed is sealed by compact 8-10 cm layer of locally available clay having impervious property. Polythene (LDPE. 0.50 mm thick) lining was provided over the clay layer and on the sides of the bed to prevent seepage of wastewater. The bed was filled with gravels (0.7 cm to 2.5 cm diameter) to enable profuse root zone development and increased hydraulic capacity.

B. Inlet and outlet arrangements:- To enhance the distribution of waste water along the full cross sectional area in the rootzone bed, horizontal PVC pipe (10 cm inch diameter) with orifices across the whole breadth was laid at the surface of the inlet. For collection of treated wastewater from the rootzone

system perforated PVC pipe (15 cm dia) was embedded in the bottom of the bed at the distal end. The treated water from the rootzone bed flows to a sump at the outlet point and is controlled by a PVC bend pipe fixed at desirable height. This helps in maintaining the water level in the gravel bed.

C. Plants: - The macrophytic vegetation play important role in functioning of rootzone treatment systems. The common Reed grass *Phragmites* species is especially suitable because of strikingly deep roots (upto 0.75 m) and rhizomes with large number of rhizospheres per unit surface area. In the present study the gravel bed was planted with reed grass-*Phragmites karka*- The density of plantation was 02 plants per square meter In about three months period the entire wetland area was coursed with *Phragmites karka (mono specie).*

Performance Evaluation - Water Quality Monitoring

In order to evaluate the waste-water treatment efficiency of the system, water quality was monitored on monthly basis at three sampling points, viz. at the inlet point, after pretreatment and at the outlet point for various Physico-chemical and Biological parameters, viz. pH, Turbidity, Total Solids(T.S.), Total Suspended Solids (T.S.S.), Total Dissolved Solids (T.D.S). Dissolved Oxygen (D.O.), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) , Total Kjeldahl Nitrogen (TKN), Ammonium Nitrate (NH_4-N), Organic Nitrogen and Nitrate Nitrogen (NO_3-N) ,Coliform bacteria etc. Standard methods by APHA-1989 were used throughout the study. TKN was determined by Kjeldahl digestion and distillation, NH_4-N and NO_3–N by steam distillation (Bremmer & Keeney, 1965) and Coliform bacteria using Most Probable Number (MPN per lit.) count .

RESULTS AND DISCUSSIONS

Constructed wetland (Root zone systems) typically require few months for growth of vegetation, biofilm establishment and sizeable time for development of litter and standing dead compartments (Billore et.al. 1999). In the present study the root zone unit was established in April 2002. It was observed that about 2 months old saplings of *Phragmites karka (*local reed grass) planted in the gravel bed in April 2002 with a density of two plants /m^2 covered the entire 700.m^2 area within a period of three months. The availability of ample nutrients in the sewage water flowing through the root zone bed (RZB) and tropical warm climate favors the growth of plants. In a period of eight months, i.e. by November2002 growth of thick vegetation with profuse roots and rhizomes was observed which enhanced the growth of associated microbes and related physico-chemical and biological process within the system.

Pretreatment

Two stage pre-treatment must be provided

i. *Screen*:-

Allowing floating materials such as polythenes, pouches, paper, wood cloth pieces, leaves etc to enter the root zone leads to clogging and unhygienic conditions. Hence, pretreatment of wastewater by way of passing through the gabion structures in the nalla served as a screen to remove all these floating material. The screened material was removed and disposed regularly.

ii. *Settling*:

The settling tank provided for preliminary treatment of wastewater before it enters the system is advantageous. As a thumb rule it may be assumed that reduction of BOD in a septic tank or primary pond for one or more day's retention is of the order of 40% due to separation of sludge from the liquid. Providing pretreatment does not mean that wetland can necessarily be reduced in size in accordance with the BOD removal. However in such cases wetland size might be reduced by 10% but not more than 20% at the most. (Wood et.al. 2000). In the present study the settling tank of 35 m^3 capacity and eight hours retention time helped in removing the sludge and settleable material to a large extent and caused reduction in solids (Total solids - between 17.9 to 23.4 %, TSS- 22.4 to 32.6 %, TDS -13.9 to 26.2 %), Turbidity 29.4 to 42,0 %, BOD 15.8 to 18.0 %, COD 23.2 to 30.5 %

Removal of Nutrients in Root zone Constructed Wetland System

The constructed wetland with horizontal subsurface flow of wastewater in a bed filled with substrate enables growth of selected plants and associated biofilm of microorganisms. The wastewater in the root zone of constructed wetland (SSF) undergoes series of physical, chemical and biological process including sedimentation, filtration, biological degradation, adsorption and nutrient uptake etc. These process result in significant reduction in suspended solids, organic compounds (BOD) etc.

Role of Substrate

The substrate is directly involved in removing pollutants through filtration, adsorption and

sedimentation (Conley et.al 1991) . The gravel bed promotes settling of suspended solids, provides surface for biofilm growth and ion exchange.

Role of Plants

The degradation of organic matter and denitrifcation of nitrogen in the root zone treatment plant is partly due to uptake of nutrients for plant growth however this is negligible as it is only very less portion of the total contents introduced in the system by the wastewater. Further the nutrients are recycled in the system upon decay of the plants Vegetation play important role in wastewater treatment The diffusion of oxygen from the roots create conditions conducive for development of microorganisms .The oxygen is transported from the atmosphere to the roots via arenchyma plant tissue. A part of the oxygen diffuses into the substrate creating aerobic, anoxic and anaerobic zones around the roots. The oxygen diffusion from the roots creates oxidized zones near the roots. Most of the organic matter is decomposed to carbon dioxide and water in aerobic zones. The ammonia gets oxidized to nitrates in these zones by nitrifying bacteria. In the anoxic zones degradation of nitrate can take place by denitrifying bacteria and nitrogen is released to the atmosphere. The simultaneous existence of aerobic, anoxic and reduced zones, interaction in various zones and microbial degradation is essential for efficient removal of nutrients in the root zone system (Brix, 1987,1993).

The extensive root system serve as large surface area for development of microorganisms and enable filtration as well as adsorption of sediments (Biddlestone 1990, Butler and Dewedar , 1991). In the Root zone treatment system the Reed grass with rhizomes and rhizospheres play key role in the treating the wastewater .The strikingly deep roots and rhizomes (down to 0.7m) create a large volume of active rhizhospheres per unit area. The important function of the *Phragmites* plants is to supply oxygen to the heterotrophic microorganisms in the rhizospheres and to increase the hydraulic conductivity of the soil. Macseneer et.al. (1982) have shown that as the roots and rhizome penetrate through the soil they loosen the soil creating increased porosity by forming pores of tubular shape. Upon decay the roots and rhizomes leave horizontally interconnected channels behind. According to Kickuth (1980) these macrospores stabilize the hydraulic conductivity in the rhizosphere at a level equivalent to coarse sand within 2-3 years regardless of initial porosity of the soil.

Microorganisms are the main agents of purification. They use organic matter and transform it into nutrients and energy (Martin and Moshiri, 1994). Diffusive and mass flow of oxygen via plant shoots and its release in plant root-zone may increase the redox potential in the substratum, enhancing the microbial decomposition and nitrification rates (Gersberg et al , 1986).

In the present study the Root zone unit was established in April 2002 and water quality monitoring was started from May 2002 on monthly basis. It was observed that though the sparsely planted saplings of *Phragmites* species grew very fast and within three months covered the entire area of 700 sq.m of the gravel bed. The water quality analysis of inlet wastewater, after pretreatment and outlet from the root zone reveals that though there was fast vegetative growth above the surface, the system took about 8 months for initial stabilization with full growth of vegetation, rhizomes, roots with rhizospheres and associated microbes when effective performance was observed.. The system showed gradual increase in performance efficiency. The average treatment performances were recorded monthly for 18 months after its installation (April 2002 to Sep 2003). **Table 1& 2** presents the average of monthly values and percentage reduction for different parameters for different periods (Nov 2002 to Feb 2003 , March to June 2003 and for Sep 2003 i.e after 18 months of installation of the unit) and graphical presentation is depicted in F**igures 1,2 & 3.** It is observed that after about 8 month's period the treatment efficiency was quite significant.

Turbidity , pH, Dissolved Oxygen

The treated water does not have any odor it is clear and turbidity is observed to be in the range of 8.3 to 25.2 NTU. The turbidity removal efficiency ranged between 83.8 to 88.4 %. The physical and chemical environment of a wetland affects all biological processes. pH, temperature and dissolved Oxygen are important factors. The pH values of influent were from 8.5 to 7.9 and that of treated water were between 8.1 to 7.0 The DO increased upto 139% with values ranging from o.85 to 3.20 mg/l, indicating aerobic conditions due to effective oxygen transfer through the rhizospheres of *Phragmitis* plants, diffusion of oxygen through the gravel bed. (Table 1&2).

Removal of Solids

The performance efficiency of the system with respective to TSS (Total Suspended Solids showed consistent increase. The value of TSS in treated effluent ranged between15.7 to 23.6 mg/l with high removal efficiency. (74.3 to 79%).The Root zone system effectively removes the solids from the wastewater. These removals take place through a complicated set of internal processes including production of transportable solids by wetland biota,

low water velocity, vegetation, substrate and filtration   (Reed et.al 1995).

Table 1: Treatment Performance of Root zone System Ekant Park, Bhopal

S.No	Parameters	Average Values Conc in mg/l Nov 2002 to Feb 2003					
		Inlet/ Raw Sewage	After Pretreatment	Outlet treated water	Treatment Performance (% Reduction)		
					PT	CW	Whole CW
1	pH	8.5 (0.47)	8.18 (0.5)	8.10 (0.35)	3.8	0.98	4.70
2	Turbidity (NTU)	154 (55.3)	108.8 (26.3)	25.2 (4.30)	29.4	76.8	83.6
3	Total Solids	164 (33.3)	125.8 (34.4)	53.8 (20.0)	23.3	57.2	67.2
4	Total Suspended Solids	81 (14)	54.6 (14.8)	20.8 (7.3)	32.6	61.9	74.3
5	Total Dissolved Solids	82.7 (26.5)	71.2 (29.0)	32.9 (13.0)	13.9	53.8	60.2
6	Chemical Oxygen Demand	308.3 (90.6)	236.8 (17.8)	72.4 (7.13)	23.2	69.4	76.5
7	Dissolved Oxygen	0.93 (0.43)	0.968 (0.22)	2.65 (1.32)	4.08	174*	185*
8	Total Kjeldahl Nitrogen	69.6 (60.0)	47.0 (30.5)	14.3 (7.2)	32.5	69.6	79.5
9	Ammonium Nitrogen	18.8 (12.4)	14.9 (8.6)	4.9 (2.4)	20.7	67.1	74.0
10	Nitrate Nitrogen	5.3 (1.9)	5.20 (2.8)	4.98 (2.9)	1.90	4.2	6.04
11	Organic Nitrogen	46.0 (52.5)	27.0 (27.0)	4.4 (6.2)	41.3	83.7	90.4
12	Biological Oxygen Demand	110.8 (54.2)	93.3 (33.2)	23.7 (4.30)	15.8	74.6	78.6
13	(E.Coli) Most Probable Number / 100ml	8×10^6	--	14×10^4	--	98.8	98.8

S.No	Parameters	Average values Conc in mg/l March 2003 to June 2003					
		Inlet/ Raw Sewage	After Pretreatment	Outlet Treated water	Treatment Performance (% Reduction)		
					PT	CW	Whole CW
1	pH	8.52 (0.22)	7.75 (0.27)	7.55 (0.23)	9.03	2.6	11.4
2	Turbidity (NTU)	91.7 (4.9)	57.4 (4.20)	12.7 (2.0)	37.4	77.9	86.2
3	Total Solids	149.4 (31.4)	122.7 (20.9)	51.9 (16.0)	17.9	57.7	65.3
4	Total Suspended Solids	94.7 (14.3)	79.4 (14.7)	23.6 (4.3)	16.2	70.3	75.0
5	Total Dissolved Solids	54.7 (9.5)	43.6 (8.42)	33.0 (6.8)	20.3	24.3	39.7
6	Chemical Oxygen Demand	211 (19.7)	150.2 (12.3)	60.1 (8.77)	28.8	60.0	71.5
7	Dissolved Oxygen	0.19 (0.36)	0.20 (0.44)	0.85 (0.67)	5.3	325*	347*
8	Total Kjeldahl Nitrogen	20.0 (2.50)	19.2 (2.3)	8.89 (1.53)	4.00	53.7	55.6
9	Ammonium Nitrogen	8.23 (1.45)	7.0 (1.73)	5.94 (1.33)	14.9	15.1	27.8
10	Nitrate Nitrogen	5.0 (2.0)	4.6 (1.9)	1.77 (0.70)	8.0	61.5	64.6
11	Organic Nitrogen	7.5 (2.3)	7.2 (2.43)	1.14 (0.85)	4.00	84.2	84.8
12	Biological Oxygen Demand	67.6 (14.7)	60.5 (13.3)	33.7 (8.6)	10.5	44.3	50.0
13	(E.Coli) Most Probable Number / 100ml	9×10^6	--	4.8×10^4	--		99.4

Note:
1. Values in parenthesis are standard deviation
2. Percentage increase
3. NTU-Nephometric Turbidity units
4. Average values for four months.

Removal of BOD and COD

The performance of Root zone bed in removing BOD is quite significant consistent. The outlet effluent is observed to have BOD levels ranging between 19.5 to 33.7 mg/l, which is comparable to secondary treatment plant. The percentage reduction of BOD was 57.0 to 78.6%. The COD reduction was 71.5 to 77.8 % and effluent COD was between 31.6 to 75.4 mg/l . BOD and COD associated with settleable solids in wastewater is removed by sedimentation while that in colloidal and soluble form is removed as a metabolic activity of microorganisms and physical and chemical interactions within the root zone / substrate. The rate of biodegradation of various organic substances depend on the temperature, oxygen concentration, pH, presence of potential strains (Wuhrman, 1992), The

BOD undergoes aerobic/anaerobic decomposition depending on the oxygen status at the deposition point (Zirschky, 1986)

Removal of Nitrogen

In constructed wetlands, nitrogen removal takes place through several processes viz plant uptake, ionic exchange, ammonia (NH_3) volatilization, nitrification-denitrification. Habrel & Perfler (1991) indicated pathway of N-removal through plant uptake as insignificant while Breen (1990) considered plant uptake as dominant mechanism of nitrogen removal. However NH_3 volatilization (Billore et..al, 1994) and nitrification and denitrification are considered to be key processes for nitrogen removal from wetland (Brix 1987,1993.Kadlex & Knight1996).

Table 2: Treatment Performance of Rootzone System Ekant Park, Bhopal

S.No	Parameters (Conc. in mg/l)	Inlet/ Waste-water	After Pretreatment	Outlet treated water	Treatment Performance (% Reduction)		
					PT	CW	Whole CW
1	pH	7.9	7.5	7.00	4.80	6.80	11.3
2	Turbidity (NTU)	72	41.8	8.30	42.0	80.0	88.4
3	Total Solids	103	78.9	30.2	23.4	61.7	70.7
4	Total Suspended Solids	75	58.2	15.7	22.4	73.0	79.0
5	Total Dissolved Solids	28	20.7	14.5	26.2	30.0	48.3
6	Chemical Oxygen Demand	142.0	98.7	31.6	30.5	68.0	77.8
7	Dissolved Oxygen	1.30	1.30	3.10	0.00	139*	139*
8	Total Kjeldahl Nitrogen	13.5	12.0	4.20	11.0	65.0	68.8
9	Ammonium Nitrogen	6.80	5.78	3.20	15.0	45.0	53.3
10	Nitrate Nitrogen	2.50	2.21	0.95	11.5	57.0	62.0
11	Organic Nitrogen	4.20	4.00	0.00	5.00	100.0	100.0
12	Biological Oxygen Demand	57.0	46.7	19.5	18.0	58.2	65.7
13	(E.Coli) Most Probable Number / 100ml	$6x10^5$	---	$8x10^3$	---	98.7	98.7

Note
1. *Percentage increase
2 . NTU-Nephometric Turbidity units

In the present study four forms of Nitrogen i.e. TKN, NH_4^+-N , NO_3^--N and Organic Nitrogen were analyzed. These nitrogen forms were significantly reduced by the root zone wetland system (**Table 1&2, Fig 1 ,2 & 3**). During the study TKN reduction was 52.7% to 79.5%, NH_4^+-N reduction was 27.8 to 74.0 %, NO_3^--N reduction was low in initial period being only 6.04% and after about one year period the system attained NO_3 removal of 64.6 % & Organic Nitrogen reduction ranged between 84.8% to 100% attaining maximum efficiency in the second year**.**
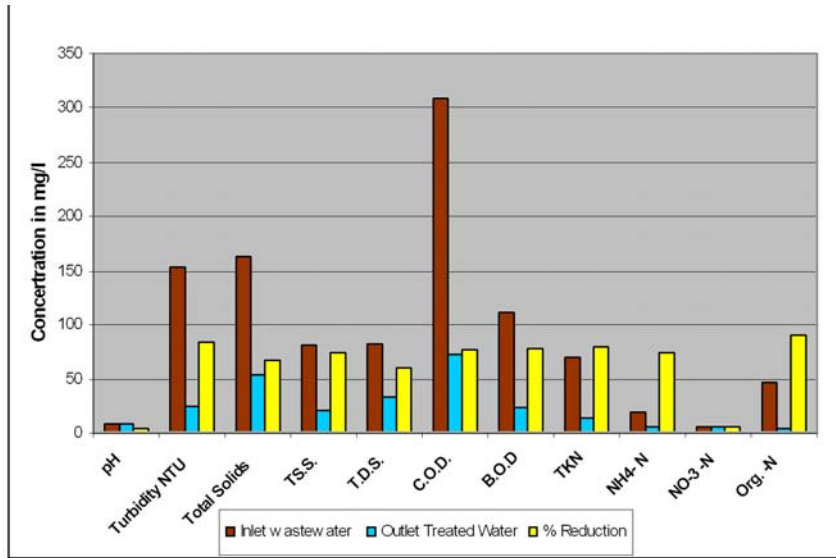
Figure 1: Treatment Performance of Rootzone System, Ekant park, Bhopal (Average Values from Nov. 2002 to Feb 2003
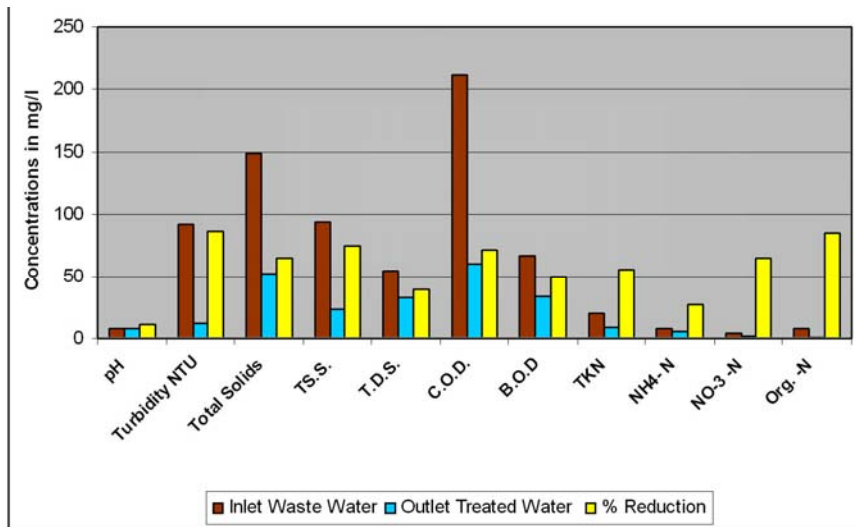

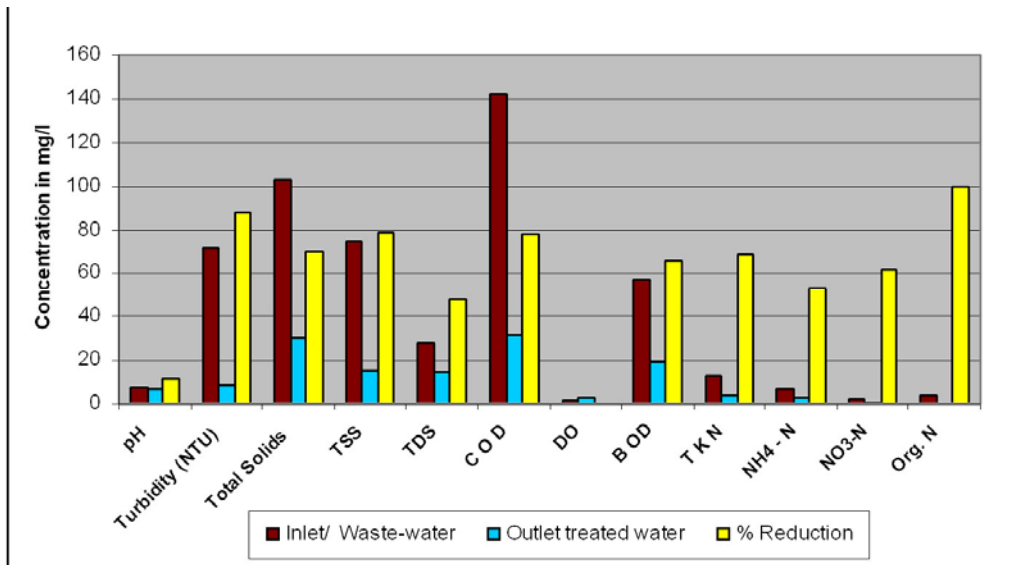Figure 2: Treatment Performance of Rootzone System, Ekant Park Bhopal (Avg. Values from March 2003 to June 2003)

Figure 3. Treatment performance of Rootzone system Ekant Park, Bhopal (Average Values of Sept. 2003)

Removal of NH_4-N upto 78.6% and TKN-59.4% has been observed by (Billore et.al.1999) while organic Nitrogen 67.5% (Billore et.al. 2002). The low nitrate removal efficiency as compared to removal of other forms of nitrogen indicate the poor denitrifying activity in the gravel bed .The significant increase of 139% dissolved oxygen in the water was observed indicating that the wetland is aerobic and more effective in DO transfer through its root-rhizome substrate .The potential for complete removal of nitrogen may require 2-3 years for plants ,root zone system litters layers, soil and benthos to reach equilibrium (Read et.ai.1995)

Pathogen Removal

The removal of organic & non-organic matter from waste water as well as bacteria *E.coli* is explained by several mechanisms. The root zone system with gravel substrate and micro-organism offer unique combination of physical, chemical & biological factors that contribute in removing & inactivating pathogenic bacteria.. Physical factors include filtration through gravel bed biofilm, sedimentation. Chemical factors include oxidation, adsorption in organic matter and biofilm .Biological removal includes ingestion by nematodes, general die off.(Gersberg 1988).The average reduction of *E. Coli* in root zone system installed at Ekant park was above 98%.

CONCLUSION

The of root zone constructed wetland established at Ekant park have shown significantly high pollution removal efficiency ranging from 65-90% for various pollutants in a period of one year. Thus it stands effective in treating the domestic wastewater .The pretreatment, i.e, screening and settling tanks facilitated the function of the system by preventing clogging , odour , flies nuisance, etc. besides adding to system efficacy.

The waste water efficiency of the rootzone (Sept.2003) system was significant within one year of its operation. The adjustable outflow helped in maintaining the water level below the surface in the root zone system .It is very cost effective ,low maintenance , eco-engineering technology .A well designed ,properly maintained & operated root zone system can be viable future technology in developing tropical country like India. It is economically viable option for treating the municipal wastewater at community level, small and medium sized towns and the treated water can be recycled and reused for secondary purposes and safe disposal in nearby water bodies.

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