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Wastewater Treatment through Root Zone Technology with Special Reference to Shahpura Lake of Bhopal (M. P.), India

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Abstract: Water quality on earth is depleted due to over increasing human development activities that over exploits and affect the quality and quantity of the water resources. The rapid urbanization has resulted in pollution of fresh water bodies due to increase generation of domestic waste, sewage, industrial waste etc. This study investigated the effectiveness and feasibility for Horizontal surface flow constructed wetland/Root Zone Unit which was constructed by Environmental Planning & coordination organization (EPCO) at Ekant Park, Bhopal. In present study samples of wastewater from Inlet and Outlet of Root Zone System situated at Ekant park, Bhopal (M. P.) were collected quarterly from June 2011 to May 2012. Some physico-chemical parameter namely dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate and phosphate were analysed using standard methods. The result obtained indicates that the Root Zone System works effectively and treated water can be used for recreational activities like washing clothes, fishing, swimming, irrigation etc.

Keywords: Root zone; constructed wetland; EPCO; BOD; COD; DO.

1. Introduction

ROOT ZONE SYSTEM's are artificially prepared wetlands comprising of clay or plastic lined excavation and emergent vegetation growing on gravel/sand mixtures and is also known as constructed wetland. This method combines mechanical filtration, chemical precipitation and biological degradation in one step for the treatment of wastewater. A number of factors like low operating cost, less energy requirement and ease of maintenance attribute to making ROOT ZONE SYSTEM an attractive alternative for wastewater management. The process in a ROOT ZONE SYSTEM to treat the sewage begins with passing the raw effluent (after removing grit or floating material) horizontally or vertically through a bed of soil having impervious bottom. The effluent percolates through the bed that has all the roots of the wetland plants spread very thickly, nearly 2,500 types of bacteria and 10,000 types of Fungi, which harbor around roots, get oxygen form the weak membranes of the roots and aerobically oxidize the organic matter of the effluent. The characteristics of plants of absorbing oxygen through their leaves and passing it down to roots through their stems which are hollow, is utilized as a bio-pump. Away from the roots, anaerobic digestion also takes place. The filtering action of the soil bed, the action with fungi etc. and chemical action with certain existing or added inorganic chemicals help in finally obtaining

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very clear and clean water. The system of plants regenerates itself as the old plants die and form useful humus. Hence, the system becomes maintenance free and can run up to 50 to 60 years without any loss of efficiency. 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 [1-3]. Alicia et. al. (1994) [4] reported that the root of some aquatic plants could retain both coarse and fine particulate organic materials present in water bodies supporting their growth.

2. Materials and methods

The present ROOT ZONE SYSTEM is situated at a geographical location of 770 35' E longitude 23025'N latitude, 460-525 m above sea level at Guru Govind Singh Park (Ekant Park) in southern area of Bhopal (M. P.), central India. The average minimum temperature during winter varies between 7°C to 14°C. During summer season the maximum temperature goes up to 45°C. The present ROOT ZONE SYSTEM is designed to treat 70,000 litres/ day of wastewater of nalla passing through the Park. This system is consists of pre-treatment (Settling tank-35 m^3) followed by Root zone bed (700 Sq. m) with gravels, Reed Plants (*Phragmitis karka*) and INLET – OUTLET arrangement for flow of water [5]. Samples were collected quarterly from INLET and OUTLET wastewater at ROOT ZONE SYSTEM, Ekant Park, Bhopal (M. P.) during the year June 2011 to May 2012. Samples were analysed to determine the working efficiency and effectiveness of ROOT ZONE SYSTEM. Samples were collected in glass containers, pre-cleaned by washing with non-ionic detergents, rinsed with tap water, 1:1 hydrochloric acid and finally with deionised water. Before sampling, the bottles were rinsed three times with sample water and then filled. The parameters such as nitrate, phosphate analysed by spectrophotometrically & dissolved oxygen, biochemical oxygen demand and chemical oxygen demand were analysed according to the methods prescribed by the APHA [6].

3. Result and discussion

The wastewater analysis of INLET and OUTLET of ROOT ZONE SYSTEM, Ekant Park, Bhopal from June 2011 to May 2012 has been carried out physiochemical parameters like, DO, BOD, COD, nitrate and phosphate were analysed and results are given in Table 1.

Table 1. Physiochemical parameters of INLET and outlet of root zone system, Ekant Park, Bhopal

S.N	Time Interval	Jun-Aug 2011		Sep-Nov 2011		Dec-Feb 2012		Mar-May 2012	
	Sampling Stations	Inlet of Root Zone	Outlet of Root Zone	Inlet of Root Zone	Outlet of Root Zone	Inlet of Root Zone	Outlet of Root Zone	Inlet of Root Zone	Outlet of Root Zone
1	DO	1.2	6.8	2.0	6.2	0.8	3.6	0.0	3.6
2	BOD	19.6	18.4	56.1	38.2	16.0	8.0	80.0	44.0
3	COD	98.0	92.0	78.0	62.0	64.0	48.0	120.0	110.0
4	Nitrate	18.4	12.2	2.5	2.0	2.7	2.2	14.3	7.6
5	Phosphate	2.8	2.8	3.0	1.6	2.4	1.8	9.0	5.8

Removal efficiency:

Removal efficiency of physicochemical parameters can be calculated using the formula,

$$\text{Removal efficiency} = \frac{\text{Input concentration} - \text{Output concentration}}{\text{Input concentration}} \times 100\% \quad (1)$$

Table 2. Removal efficiency (%) of root zone system

S.N.	Time Interval	Jun-Aug 2011	Sept-Nov 2011	Dec-Feb 2012	Mar-May 2012
1	BOD	6.12	31.9	50.0	45.0
2	COD	6.12	20.51	25.0	8.33
3	Nitrate	33.69	20.0	18.51	46.85
4	Phosphate	0.0	46.66	25.0	35.55

3.1. DO

In present study, the DO value varied from 0.0mg/L to 2.0 mg/L in INLET and 3.6 mg/L to 6.8 mg/L in OUTLET of ROOT ZONE SYSTEM. The minimum value of DO at INLET was observed as 0.0 mg/L during the month of Mar-May 2012 and maximum was noted as 2.0 mg/L during the month of Sep-Nov 2011. The minimum value of DO at OUTLET was observed as 3.6 mg/L during the month of Dec-Feb 2012 and Mar-May 2012 whereas maximum was noted as 6.8 mg/L during the month of Jun-Aug 2011. For drinking water DO limit is 6.0 mg/L according (WHO, 1968) [7].

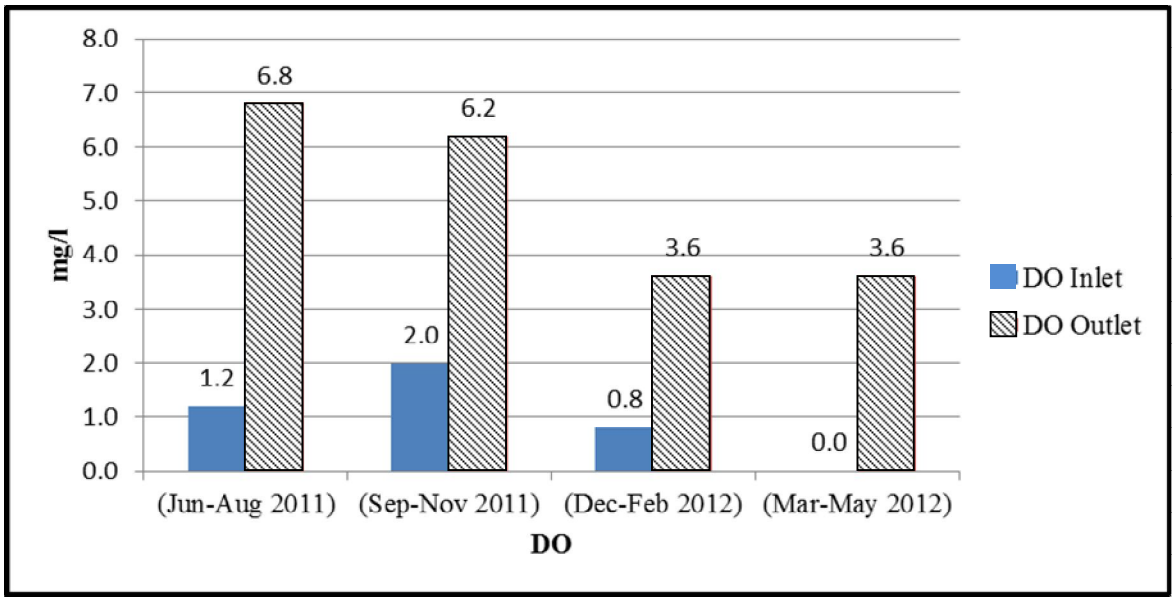

Figure 1. Quarterly variation of DO in inlet and outlet of root zone system

3.2. BOD

The amount of oxygen from water to break down of organic and inorganic wastes and sewage is known as biochemical oxygen demand (BOD). The more oxygen taken out from water the less becomes the content of dissolved oxygen, thus, increasing the pollution in lake with a high BOD load. The amount of DO needed by bacteria to decompose the waste determine the quality of wastewater. In present study, the BOD value varied from 16.0 mg/L to 80.0 mg/L in INLET and 8.0 mg/L to 44.0 mg/L in OUTLET of ROOT ZONE SYSTEM. The minimum value of BOD at INLET & OUTLET was observed as 16.0 mg/L & 8.0 mg/L during the month of Dec-Feb 2012, whereas the maximum value of BOD was observed as 80.0 mg/L & 44.0 mg/L during the month of Mar-May 2012. BOD indicates the presence of microbial activities and dead organic matter on which microbes can feed. An inverse relation was found between the DO concentration and BOD values [8]. The overall removal efficiency of BOD was varied from 6.12 to 50.0 & maximum value was recorded during the month of Dec-Feb 2012.

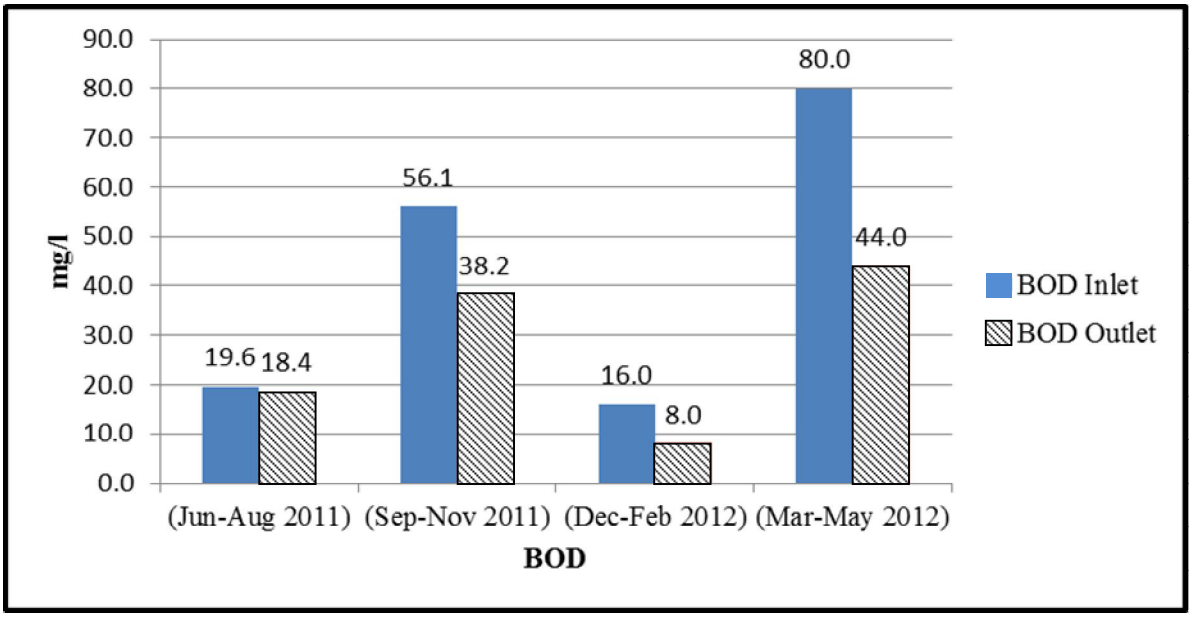

Figure 2. Quarterly variation of BOD in Inlet and outlet of root zone system

3.3. COD

In present study, the COD value varied from 64.0 mg/L to120.0 mg/L in INLET and 48.0 mg/L to 110.0 mg/L in OUTLET of ROOT ZONE SYSTEM. The minimum value of BOD at INLET & OUTLET was observed as 64.0 mg/L & 48.0 mg/L during the month of Dec-Feb 2012, whereas the maximum value of BOD was observed as 120.0 mg/L & 110.0 mg/L during the month of Mar-May 2012. The maximum limit of COD For drinking water is 150 mg/L [9]. COD is more realistic parameter, which indicates the pollution status of water body as it is related with the allochthonous matter present in lake [10]. The overall removal efficiency of COD was varied from 6.12 to 25.0 & maximum value was recorded during the month of Dec-Feb 2012.

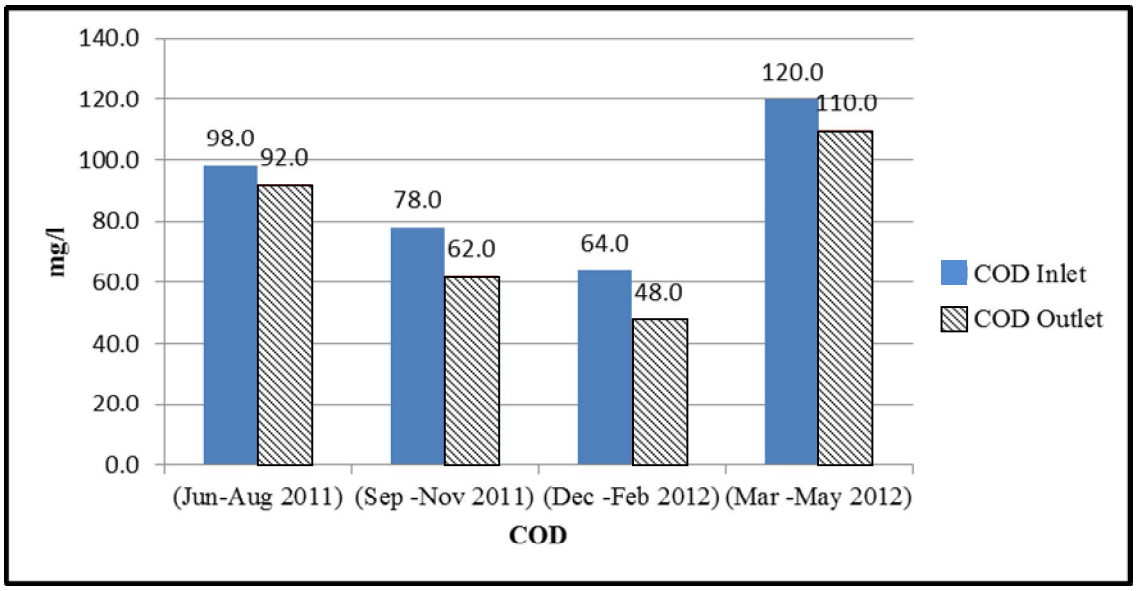

Figure 3. Quarterly variation of COD in Inlet and outlet of root zone system

3.4. Nitrate

Nitrate is one of the important pollution indicator parameter. Nitrate is effective plant nutrient and moderately toxic and is considered important for its adverse health effects. In present study, nitrate concentration varied from 2.5 mg/L to 18.4 mg/L in INLET and 2.0 mg/L to 12.2 mg/L in OUTLET of ROOT ZONE SYSTEM. The minimum value of nitrate at INLET & OUTLET was observed as 2.5 mg/L & 2.0 mg/L during the month of Sep-Nov 2011, whereas the maximum value of nitrate was observed as 18.4 mg/L & 12.2 mg/L during the month of Jun-Aug 2011. A limit of 45 mg/L has been prescribed by BIS [11] and WHO [12] for drinking water supplies. The overall removal efficiency of nitrate was varied from 18.51 to 46.85 & maximum value was recorded during the month of Mar-May 2012.

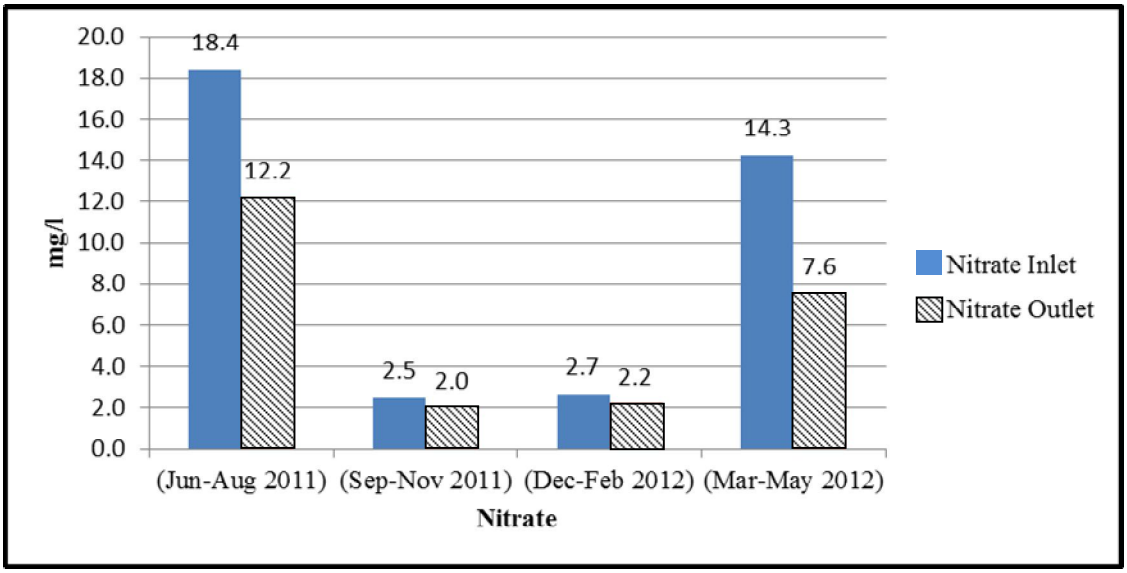

Figure 4. Quarterly variation of nitrate in inlet and outlet of root zone system

3.5. Phosphate

Phosphate is important nutrient in the lake for eutrophication process. Phosphate is the indicator of some algal growth, which is not good for Lake Environment. In present study, phosphate concentration varied from 2.4 mg/L to 9.0 mg/L in INLET and 1.6 mg/L to 5.8 mg/L in OUTLET of ROOT ZONE SYSTEM. The minimum value of phosphate at INLET & OUTLET was observed as 2.4 mg/L & 1.6 mg/L during the month of Dec-Feb 2012 & Sep-Nov 2011, whereas the maximum value of phosphate was observed as 9.0 mg/L & 5.8 mg/L during the month of Mar-May 2012. The overall removal efficiency of phosphate was varied from0.0 to 46.66 & maximum value was recorded during the month of Sept-Nov 2012.

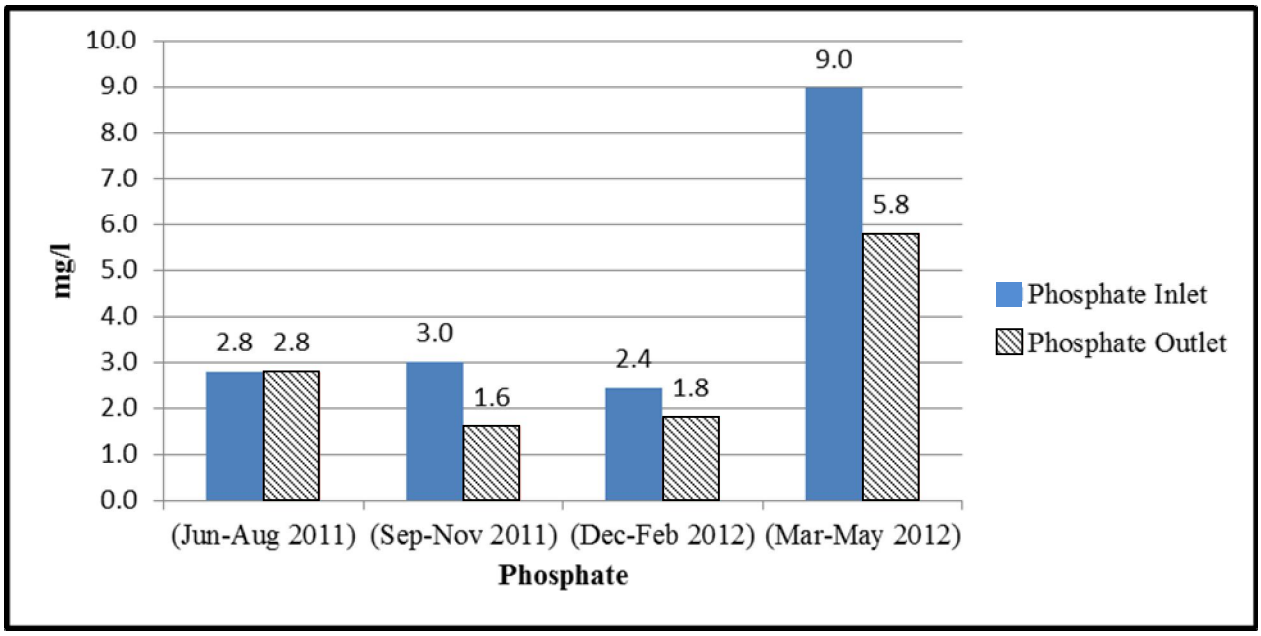

Figure 5. Quarterly variation of phosphate in inlet and outlet of root zone system

4. Conclusions

The present study clearly proves that the water quality during Root Zone treatment improves a lot which is indicated by reduction in BOD, COD, nitrate & phosphate value and increase in DO value. Thus it stands effective in treating the wastewater.

It is concluded that the ROOT ZONE SYSTEM at Ekant Park, Bhopal is working effectively to treat the wastewater and the treated water can be reused for secondary purposes like fishing, swimming, irrigation etc. and safe disposal in nearby water bodies.

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