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ANALYSIS OF INLET AND OUTLET WATER QUALITY OF DOMESTIC WASTE WATER TREATED WITH ROOT ZONE METHODS (RZM)

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ABSTRACT

Present study was aimed to evaluate the water quality of inlet and outlet water discharged from the home and after coming to the Constructed wetland it will be treated by roots of special plant. Different physical, chemical and biological parameters were evaluated for the assessment of water quality. Physical parameters such pH, temperature, conductivity, were significantly decreased. While in case of COD, phosphorus, total Nitrogen, BOD, DO, reduction was about 90% in the treated water. Experiments were conducted in the consecutive three seasons i.e., rainy season (July to October), winter season (November-February) and summer season (March-June) of two years. Results revealed that there is significant decrease in pollution load in inlet water treated with root zone method. Although it was a study to provide qualitative analysis but results are quite promising. Overall the study supports the effective, ecofriendly and economical technology for the treatment of domestic waste water.

Keywords: COD, Constructed Wetland, RZT

INTRODUCTION:

India is a country where water pollution is a big problem faced in recent past. Although, there is a huge amount of fresh water in the form of rivers and lake present but pollution of these water bodies is a threaten sign in near future. Water pollution is commonly considered by two ways and its treatment Wastewater treatment refers to the treatment of sewage and water used by residences, business, and industry to a sufficient level that it can be safely returned to the environment. In recent years, various pollution are spreading in the society and we are very aware environmentally, and going for the green and clean technologies to treat pollution. One such technology for wastewater treatment is Constructed Wetland which has become very popular in last 20-25 years [1,2,3]. The wastewater treatment technologies are shifting towards bio-eco-engineering technologies, which are a new field in the science of ecology and wastewater treatment [4].

Constructed wetland with root zone method is used as an effective waste water treatment in recent past. Root zone in the cosntructed bed is most active and here the interaction of plants, microorganisms, the soil and pollutants takes place. Root zone method is green revolution in wastewater treatment. Prof. R. Kickuth, from the University of Herren in Germany in early 1960 who had developed RZM system. Root zone method is tpical example of human-made ecofriendly construction with different sized stones and gravel filters. In the above context three interdependent subunits of the system are the reeds (*Phragmite*s), bed and microorganisms. The pollutants in this system are removed through the combination of physical, chemical, and biological processes including sedimentation, precipitation, adsorption of soil particles, assimilation by the plant tissue and microbial transformations [5,6,]

This paper present some aspects of effect of RZM in the reduction of total solid, BOD, COD, total nitrogen and DO from domestic wastewater. A detail methods used during the tenure was discussed in the next section.

MATERIAL AND METHODS

Present study was conducted at School of Studies in Botany, Vikram University, Ujjain. The selected wetland unit was built during 2000 on the abandoned play ground of the Education College receiving the outfall of the sewage from the Ravindra Nagar residential colony in Ujjain (23^0 12' N latitude, 75^0 42'E longitude, mean sea level 515.45m), located in the central part of Madhya Pradesh state, India, with treatment capacity of approximately 40,000 liter wastewater/day. Domestic waste water is collected in the wetland and filtered through root zone of *Phragmitis karka* grass. For the present study a field scale one celled horizontal subsurface flow (HSF) constructed wetland was selected. For the testing of waste water and treated water two sites were selected i.e., inlet and outlet. Further methods were used as follows:

Sampling procedure: At each site 500 ml water sample was collected. For the collection sterilized glass stoppered BOD bottles were used. In the first step, the glass stoppered 500 ml bottle was washed thoroughly and rinsed with distilled water, for microbial analysis each dry bottle was rinsed with 0.5 ml sodium thiosulphate (10% solution) neutralized residual chlorine. Then stopper was loosely placed in the neck of bottle, wrapped in paper and sterilized at 121^oC for 15 minutes.

Physical parameters: The important physical characteristics of untreated and treated wastewater were included: Temperature, Conductivity, Total Solid, Total Suspended Solid, and Total Dissolved Solid as per APHA Method [7].

Temperature: For the measurement of temperature glass thermometer was used. At the site thermometer dipped into the water and reading was noted and average value was calculated.

Conductivity: Conductivity was directly measured with conductivity meter by immersing the electrode in the water samples. The results were expressed in µs/ms.

Total Solids: The total amount of dry matter was ascertained gravimetrically by evaporation of 20ml wastewater sample in a 100ml Borosil beaker at 103^0C and weighing of the residue as per accordance given in the Standard Methods for Water and Wastewater [7].

Total Suspended Solid: The proportion of suspended solids was measured by filtration of 20 ml sample of wastewater by 1 no. Whatmann filter paper and this was weighed at both time, before use and after heating at 103^0 C and calculation has been done by this formula [7].

Total Dissolved Solid: Twenty ml of wastewater filtered by No.1Whatmann filter paper with the help of vacuums pump and filtrate was kept in the oven at 103 ± 2^0 C for 24 hours. Before and after weights taken concentrations of dissolved solids were calculated as follows [7].

Chemical Parameters: Different chemical parameters are considered as pollution indicator such as Dissolved oxygen, Chemical Oxygen Demand, and TKN (Total Kjeldahl Nitrogen) few of them and assessed in the present study.

Dissolved Oxygen: DO was determined by modified Winkler's Method [7].

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Chemical Oxygen Demand: For the purpose of COD analysis of Root Zone Method (RZM) water, open reflux method adopted from the [7].

Total Kjeldahl Nitrogen Method: The sum of total nitrogen was determined by Kjeldahl method by digesting the 10 ml of sample of wastewater with concentrated sulphuric acid and selenium catalysis (potassium sulphate + copper sulphate + selenium metal) and standard dilute sulphuric acid was used as tatrate to standard methods [7].

Statistical Analysis: All data collected, compiled, and analysis for the significance difference and standard deviation using *Biostat* Software. The results of statistical analysis are expressed as standard deviation and 't' value.

RESULTS AND DISCUSSION

Physical and chemical parameters of water quality were analysed in inlet and outlet water of wetland constructed in Ravindra Nagar, Ujjain. Three seasons- **rainy season** [July to October] **winter season** [November to February], and **summer season [**March to June]. In case of physical parameters the results are expressed in units of each specific parameter. Apart from the pH, values of all other parameter were expressed as mg/l. As indicated in the **Table 1** The values of temperature were higher during the summer season and lower during the winter season at the both sampling points .The average values of temperature recorded were 22.44^0C of inlet water and 19.25^0C of outlet water, respectively.

There are different physical, chemical and biological processes takes place in and around the roots of the plant in constructed wetland. It was reviewed by earlier workers that diffused oxygen in the roots of reed bed vegetation creates pleasant conditions for growth and activity of microorganism. Due to this degradation of organic matter takes place [8]. These processes result mainly in reduction of turbidity, conductivity, TS, TSS, TDS, total nitrogen contents etc and removal of microbial pathogens. Such man-made CWs were previously used for treatment of wastewater in different countries [9, 10, 11, 12, 13,14, 15] and also in India [16].

Table 1 Average seasonal data of Temperature (°C) with 't' values and their significant level

Season	Inlet Water	Outlet Water	% Reduction /Change	't' value	Remarks (significant)
Rainy	22.5	18.9	16	-	-
Winter	20	17.3	14	-	-
Summer	24.7	21.4	13	-	-

As depicted in the Table 2 that the variation in the conductivity range from 1.78 ms to 0.8 ms in rainy season with removal efficiency of 55%, 1.82 ms to 0.78 ms in winter with removal efficiency of 57% and 2.17 ms to 0.87 ms in summer with removal efficiency of 60%. The average conductivity reduced up to 57% in treated water. This indicates significant reduction in soluble solid, nutrients and minerals and fluctuation in various seasons may be due to rainfall, runoff and evapotranspiration**.**

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Table 2 Average seasonal variation in Conductivity (ms) with 't' values and their significance

Season	Inlet Water	Outlet Water	% Reduction /Change	't' value	Remarks (significant)
Rainy	1.78(0.58)	0.8(0.29)	55	4.246	Significant
Winter	1.82(0.57)	0.78(0.26)	57	4.604	Significant
Summer	2.17(0.45)	0.87(0.28)	60	6.862	Significant

The seasonal variation and treatment of total solids, total suspended solids and total dissolved solids in inlet and outlet points are shown in **table 3, 4** and **5** respectively. The average value of TS in inlet water was 1214.42 mg/l and outlet 405.66 mg/l (**Table 3**) and the average percentage reduction of TS from inlet to outlet was 67% which indicates significant treatment performance. The mean value reduction of TS in this system was 66% in rainy, 66% in winter and 68% in summer respectively**.** In the similar trends the average values of TSS from inlet and outlet was 620.08 and 229.91 mg/l, respectively with 63% reduction (**Table 4**). As indicatd in the **Table 5** total dissolved solids ranges from 423 to 750 mg/l in untreated and 150 to 205 mg/l in treated water with annual means of 594.33 and 183.87 mg/l in inlet and outlet respectively with 69% reduction from inlet to outlet**.**

Table 3 Average seasonal variation in T.S. (mg/l) with 't' values and their significant level

Season	Inlet Water	Outlet Water	% Reduction /Change	't' value	Remarks (significant)
Rainy	1183.7 (143.20)	404.8 (39.80)	66	14.82	Significant
Winter	1231.8(137.65)	415.3 (66.91)	66	15.09	Significant
Summer	1227.6 (104.54)	396.7 (67.94)	68	18.85	Significant

Table 4 Average seasonal variation in T.S.S.(mg/l) with 't' values and their significant level

Season	Inlet Water	Outlet Water	% Reduction /Change	't' value	Remarks (significant)
Rainy	596.5 (53.54)	222.6 (41.44)	63	15.62	Significant
Winter	633.1 (75.49)	228 (62.96)	64	11.66	Significant
Summer	630.6 (79.97)	239.1 (48.92)	62	11.81	Significant

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Table 5 Average seasonal variation in T.D.S.(mg/l) with 't' values and their significant level

Season	Inlet Water	Outlet Water	% Reduction /Change	't' value	Remarks (significant)
Rainy	587.2 (118.41)	181.6 (17.26)	69	9.587	Significant
Winter	598.7 (89.03)	187.3 (9.11)	69	13	Significant
Summer	597 (46.34)	182.6 (11.93)	69	24.49	Significant

Dissolved oxygen is obviously essential to the metabolism of all aquatic organisms that undergo aerobic respiratory biochemistry [17] and several reasons make Oxygen an essential element to plants roots.

The most important requirement is as a source of energy for root respiration. Oxygen deficiency in itself will not kill roots as deficient supplies of oxygen can usually maintenance respiration even in plants without especially evolved oxygen transport system. The second requirement for an oxygen diffusion system are aquatic macrophytes which oxidize many toxic compounds in the rhizosphere. Many of these toxic compounds inhibit plant growth. The minimum values of DO was (1.0 mg/l) observed during summer season at inlet point and highest value 3.0 mg/l in winter season at outlet point. The average values of DO was 1.35 mg/l in inlet point and 2.78 mg/l in outlet point, which indicates 106% increase in DO after the treatment (**Figure 1**). This increase in DO is due to photosynthetic activity by algal flora and diffusion by plant roots in sub-surface water.

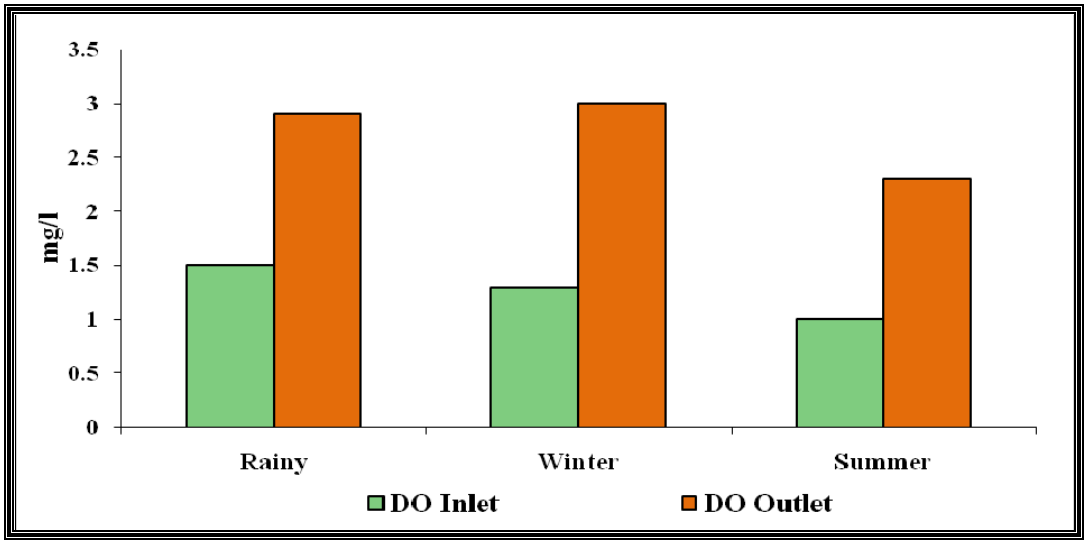

Figure: 1 Average seasonal variation in DO of inlet and outlet water (mg/l)

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According to [18] significant aerobic regions are required in the bed in for the nitrification and other vital microbially induced removal mechanisms and to avoid build-up of an aerobically induced toxins.

The overall reduction of Total Kjeldahl Nitrogen was 75% in winter 74% summer and 67% in rainy season respectively (**Figure 2**). Mechanism involve in the nitrogen removal are stripping of NH_3, nitrification/denitrification and sedimentation after biological nitrogen uptake [19]. This significant reduction in TKN is considered due to aerobic and anaerobic denitrification, plant uptakes, volatilization and biofilm immobilization. During study, TKN reduced by 72%, in outlet water as compared to intlet water of this constructed wetland and similar types of results were obtained by earlier researchers also [20, 21]

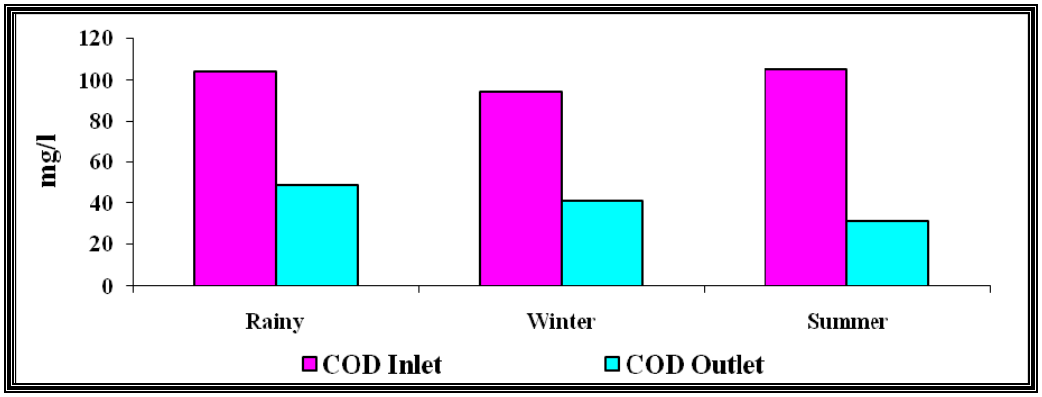

Figure 2 Average seasonal variation in COD of inlet and outlet water (mg/l)

The highest COD reduction 70% was during summer season (105 mg/l to 31.2 mg/l), followed by winter season 56% (94.3 mg/l to 41.2 mg/l), and least reduction of 53% was observed during rainy season (104.1 mg/l to 48.5 mg/l) (**Figure 2**). The average values of COD in inlet water were 101.16 mg/l and this got reduced to 40.33 mg/l in the outlet water and means 60% reduction was observed in the treatment system. Reduction in COD in outlet water of the system indicates that chemical processes are going on properly.

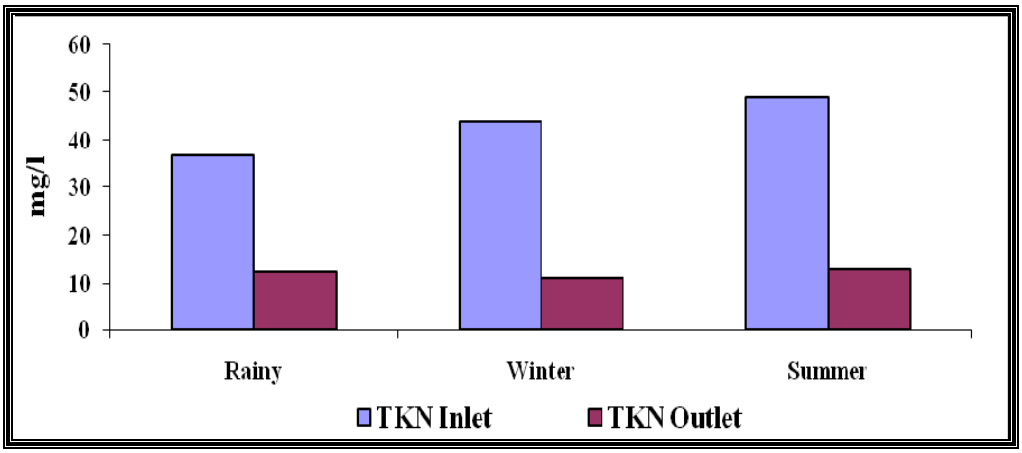

Figure 3 Average seasonal variation in TKN of inlet and outlet water (mg/l)

Total solids reduction in outlet water is expected due to the excellent performance of reed bed in providing aerobic zone around roots and rhizome of *Phragmites* which enhance microbial activity decomposing soluble and suspended organic matter and then their settlement. These processes also cause reduction of turbidity. Reduction in temperature may be due to the factor that water is exposed to sun before coming to inlet but not so before coming to outlet.

CONCLUSION

As indicated in the present paper that the most effective, ecofriendly, cost efficient method is found to be RZM. Domestic waste water and other industrial effluent can also be treated with this technology. The present study also support that COD, BOD load in the water can be easily reduced at optimum level with RZM.

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