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Treatment of domestic wastewater by Cattail (*Typhalatifolia*) based natural wetland system in southern locality of Ujjain city in central India

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Abstract-The treatment performance of a natural wetland (surface flow) was evaluate for the removal efficiency of Conductivity, Salinity, Turbidity, TS, TSS, TDS, TKN, $NH4^+$-N, COD and BOD from municipal wastewater emanating from a southern locality of residential area in Ujjain, central India. These surface flow natural wetland had a rectangular size and covered in effective surface area of 1260 m^2 (length 90 m x width 14 m) with a water retention capacity of 650 m^3 approximately. The surface flow medium was composed of gravel/stone, soil and mud. Natural wetland support a dance and dominant vegetation of Cattail (*TyphaLatifolia*) in the Nullah bed throughout the year, *TyphaLatifolia*. Total plant of Cattail were 36540 (as average annual density 29 plants / m^2) available and 6787 grams/m^2 biomass of the plant recorded . The removal rate of Conductivity, (51.5%), Salinity (51%), Turbidity (65%), TS (61%), TSS (59%), TDS (63%), pH (7.3%), TKN (53%), $NH4^+$-N (52.7%), COD (57%), and BOD (47.3%) were realized. An earthen channel provided initial pre-treatment by land treatment system. DO of effluent level increase to 74% indicating. It is indicating existing of aerobic condition in plant rooted bed. This SF system overall result established (A.) very cost effectively technology. (B.) SF removal efficiency above 50% for all parameters.

Key words-Wastewater, natural wetland, water quality, Dissolve oxygen, Total solids, TKN, sedimentation

I. INTRODUCTION

Water is a vital component for sustenance of life. It governs almost all our activities be it domestic, industrial or of agricultural needs. These activities generates enormous amount of wastewater. The wastewater of industries domestic origin, surface runoff and storm-water of catchment is ultimately discharged into receiving water body of the concerned catchments. The water scarcity is increasing day by day due to lots of reasons. These may be social, economic and geological precipitation deficiency more depended on ground water/exploitation for increasing land area as agricultural and aquaculture practices. So it is very safe and wise use of treated water or reuses of water. The Municipal wastewater in Ujjain city is characterized by high concentration of total solids, biochemical oxygen demand and total nitrogen (Particularly the NH_4^+-N [1,2,3]. *TyphaLatifolia* is highly productive aquatic plants that grow in a variety of habitats throughout wetland worldwide. They are able to occupy ponds and lake margin, fresh and brackish marshy discharge and reservoir contaminated with industrial water. All the species that occurs in the central India in Ujjain city. The *Typhalatifolia* broad leaf Cattail with thick and spreading rhizomes, is restricted to shallow water. At Ujjain the nutrient rich sewage, agricultural runoff and stormy water sewerage, directly merges into the river Kshipra passing through wastewater channel having certain pockets of natural wetland at MR-II area Ujjain of central India [4].

Wetland which we naturally occurring inundated or saturated area. The major functions of natural wetland are flood control, binding effects of their vegetation, ground water recharge, immobilization and transformation of a wide range of environmental contaminants and nutrients. Its also acts as sink for preventing nitrate build up. Natural wetland considered as they are the kidney of the world. Natural wetlands purify water by acting like a sponge soaking up rainwater that runoff the land before it Enters rivers and streams.

The extensive roots means of wetland plants and the soil itself work together to extracts contaminants and nutrients from water. These natural cleaning process of wetlands help keep our rivers, streams and ocean clean water wise [5]. Broadleaf Cattail (*Typhalatifolia*) is a cosmopolitan species found in North America, Mexico, Great Britain, Eurotia, India, Africa, New Zealand and Australia. It is typical of early serial, open canopy, communalities. It occurs immediately or soon after disturbance in most of wet

habitats and occurs in the primary succession of open water or debris flows.

The rest of the paper is organized as follows. Secton I- Introduction, Secton II- Related work, Secton III- Methodology, Section IV- Result and Discussion and Section V- Conclusion and Future scope.

II. RELATED WORK

Natural Wetlands are able to provide high levels of wastewater treatment [6,7,8]. Long retention time and an extensive amount of sediment surface area in contact with the flowing water provides for effective removal of particulate matter. The sediment surfaces are also where most of the microbial activity affecting water quality occurs, including oxidation of organic matter and transformation of nutrients.Natural Wetlands are, however, characterized by extreme variability in functional components, making it virtually impossible to predict responses to wastewater application and to translate results from one geographical area to another.

Although significant improvement in the quality of wastewater is generally observed as a result of flow through Natural Wetlands, the extent of their treatment capability is largely unknown. The performance may change over time as a consequence of changes in species composition and accumulation of pollutants in the wetlands [9]. Therefore the treatment capacity of Natural Wetlands is unpredictable. There are too few data from natural systems to allow confident predictions of the treatment performance of the systems and the effects of wastewater discharge on receiving ecosystems [10]. There has also been concern over possible harmful effects of toxic materials and pathogens in wastewaters and long-term degradation of wetlands due to additional nutrient and hydraulic loadings from wastewater. Thus Natural Wetlands are not appropriate a large-scale wastewater treatment system, but should be preserved for environmental conservation.

III. THE STUDY SITE AND SAMPLING PERFORMANCE

METHODOLOGY: THE STUDY SITE AND SAMPLING

Site study : The presents study site is located in a wastewater channels (Nullah) of which receives a sizable amounts of wastewater amanating from the Vikram University campus, Rishi Nagar colony and Mahakal Commercial Area supporting a population of around 1 lakh. This population belong to southern locality of Ujjain cit. the domestic wastewater channels has certain pockets of *Cattail plant*. This cattail plant to certain Natural wetland system is located in upstream of wastewater nullah on MR-II road site in Mahankal Commercial Area at Ujjain city with (23°12'N latitude, 75°42'E longitute, mean sea level 515.45 m.). The Ujjain city is located in the Central Part of India in the Madhya Pradesh state. The climate of the area is typically monsoon receiving 1032 mm. rain annual, confined exclusive during July to September, the rainy seasons. The Annual maximum and mean temperatures were 31.4 and 16.5°C respectively. Across the length of Nullah, patch of natural wetland (size 90m length x14m width= 1260m^2) already existed in the wastewater channel was selected for the present study and been coded as site no 1. Ultimately the wastewater channel of in traversing about 7 km. meets in River Khipra in Gaughat area. The wetland supports a dense and dominant vegetation of Cattail, *Typhalatifolia*in the Nullah bedthroughout the year. The system consists of a soil and mud bed over which the wastewater flows. The age of the Nullah is approximately 40 years.

Natural Wetlands purify water by acting like a sponge, soaking up rainwater that runs off the land before it enters rivers and streams. The extensive root mass of wetland plants and the soil itself work together to extract contaminants and nutrients from water. These natural cleaning processes of wetlands help keep our rivers, streams and oceans clean.

The treatments performance of Natural wetland evaluated by comparing the water quality characteristics (Physical, Chemical and Biological contact) at two sampling point. Sampling point 1 (SP I) located at 90 m. aparts from natural wetland in the upstreams receiving the input from adjoining areas, sewage stream and sampling point 2 outlet (SP 2) lying below the end of natural wetlands. Grab samples were brought from June 2008 to May 2010 in plastic containing canes except during the rainy season which causes and swift flow in river water (July to September). Monthly samples of June 2008 to May 2010 were collected from upstreams of Natural wetland at inlet (SP-1) and outlet (SP-2) for the two year study period. These collected sample were analyse for analyzed for Temperature Conductivity, Salinity, Turbidity, TS, TSS, TDS, pH, DO, TKN, NH_4^+-N, COD and BOD parameter applying standard method in order to estimate the performance of Natural wetland System in reductions of the mentioned water quality parameters [11].

IV. RESULTS AND DISCUSSION

All important physical, chemical and biological characteristics of water quality were analyzed for inlets (Untreated- domestic wastewater) and outlets (Treated-domestic wastewater) of Natural wetland points. The water sample from this system were analyzed monthly and presented as average values of the total values recorded in the consecutive two years i.e. from June 2008 to May 2010. The results are analyzed and data are expressed by table and Figure (Table no. 1 and Figure no. 1) The results have been

also statistical analyzed, which shown as Standard Deviations (Sd) and 't' values.

Temperature is one of the most widely fluctuating abiotic factor which effects all physical, chemical and biological processes temperature varies in both inlet and outlet waters of the Natural system as per seasons. The average value of temperature recorded were 20°C of inlet and 18.3°C of outlet. The average reduction in Temperature from Inlet to outlet was 8% seen. It is higher in inlet (about 10%). Temperature varies both in inlet and outlet waters of the Natural wetland system as per season. But generally it is higher in inlet (about 8~10%) as it is constantly exposed to sun while outlet water passed through natural soils gravels and reed bed of NW. Before it is taken for analyses and exposed tosun, hence generally temperature was lower in outlet water [12,13].

The average Conductivity, Salinity and turbidity was recorded from 1.28 to 0.62 ms, 12.8 to 6.29 ms^2 and 160 NTU to 57 NTU in inlet to outlets of NW system. The average reduction up to 52%, 51% and 65% respectively has been observed. This indicates the significant reduction in soluble solids, nutrients and minerals and fluctuation in various seasons may be occurred due to rainfall. Conductivity and salinity indicate amount of soluble total solids in wetland water. The total ionic salts are somewhat altered by biological, physical and environmental conditions. Therefore, conductivity may be relatively inaccurate due to soluble solids effected by rainfall, run-off and evapotranspiration in wetland treatment system. The present results support the earlier findings[14,15].

The range of concentration of different solids : TS, TSS and TDS varied in inlet and outlet water during the two year study of research. The overall reduction of different solids is TS by 61%, TSS by 59.4%, and TDS by 63.1% respectively by Natural wetland systems.

The results were also statistically tested by using students ‘t’ test as 5% and 10% level. These removals are the end of results of complicated set of internal processes, including the production of transportable solids by wetland biota, low water velocity coupled with the presence of vegetation or gravel substrate (Sediments) which promote fall out and filtration of different solid materials. This transfer of SS from water to sediment bed has important results both for quality of water and properties and function of the wetland system as also expressed earlier [7].

The removal of suspenses solid is considered to occurs. Through entrapment in the plants roots zone and by gravity sedimentation in the quiescent water beneath. Plants seem to constitute a substratum for the fixation of decomposing microorganism that act as filter for the dissolved organic matter. Thus the present work is in accordance with earlier. Findings [16,17]. Earlier there was a potential problem of suspended solids was that they can lead to the development of sludge deposits when untreated wastewater is discharged in the aquatic environment without any emergent plants. In the subsurface flow (SSF) wetlands, wastewater suspended solids are removed primarily by filtration through the substrate media [18].

Chemical parameter pH is considered to be comparatively stable during different study months. In inlet (untreated) and outlet (treated) wastewater of Natural wetland was difference of 7.3%.
In treated water controls points, the dissolved oxygen got increased. It was notes that the DO was increased to 73.8% in treated water of Natural wetland systems.

DO increase in wastewater; reflects to purity. It occurred due to removal of various organic matter and releasing oxygen in root/rhizome in the soil by the existing plants species [19,20,21,22]. These results of DO contents tested by applying student 't' test found significant.

The large root system in Typha may have been responsible for adequate oxygen transport for the nitrification of NH_4^+-N to NO_3 before it got denitrified TKN may have been partly mineralized or lost to sediments within the system [23]. Volatilization may result in some loss of ammonia from the wetlands but generally occurs at higher pH and under ponded condition [24]. In the present study average reduction in the NH_4^+- N 52.7% was calculated by NW of Typha in untreated to treated wastewater.

However, there is Growing evidence that NH_4 can be lost by anamnox process (anerobic ammonia oxidation [25]. Under anaerobic condition anammox process appears to dominate for significant removal of ammonia nitrogen. This generally involves NO_2 as the donor ion for the oxidation of NH_4 into dinitrogen gas [24]. In this process NO_3-N (product of chemolitho-autotrophic nitrification) gets depleted in the upper few centimeters of the media. Since anammox uses nitrite as the electron acceptor, nitrate is first reduced to NO_2 and then both are lost through anammox process. This is more likely pathway considering the loss of large amounts of NH_4^+- N together with NO_3^- N, and the limitation on oxygen transport to the roots.

TKN untreated to treated wastewater reduced by 53%. Considering COD, significantly lowered/reduced amount in outlet wastes as compared to inlet water of this NW system was recorded. The removal of COD by this wetland system was primarily a function of the mount component. The processes involved are probably filtration, sedimentation, oxidation, adsorption and biological degradation. The significant man removal efficiency of COD in Natural wetland observed was 56.8%. It is due to decomposition of organic matter and developing aerobic condition in wetland

beds [21,13]. Among biochemical parameter the biological oxygen demand (BOD) indicates measures of oxygen consumption by microorganism in the oxidation/degradation of organic matter. BOD was significantly (at p = 0.05 level). Reduce form untreated wastewater Inlet to treated water outlet by this NW system. These reductions were more during summer months than in water months (37 - 44%). As all microbial components of wetlands are more active during high temperature [12]. Annually BOD reduction in experiment Typha based wetland bed is 47.3%. A colloidal and dissolved form continues to be removed as wastewater comes in contact with attached microbial growth in the system. Horizontal subsurface flow natural wetland can effectively treat high level of biological oxygen demand (BOD) and suspended solids (SS) the basic treatment mechanisms include sedimentation, chemical precipitation, adsorption and microbial interactions with BOD as well as uptake by vegetation [17].

Table 1- The Average Values of physical, chemical and biological parameters of wastewater treatment in Natural wetland treatment system during the study period (June 2008 to May 2010).

PARAMETERS	INLET- Untreated wastewater	OUTLET- Treated wastewater	%REDUCTION("t" VALUE) SIGNIFICANT
Temperature(^{0}C)	20 (3.92)	18.33 (3.91)	8.35 (0.9017) NS
Conductivity (ms)	1.28 (0.22)	0.62 (0.15)	51.56 (7.152) S
Salinity (mS/cm^2)	12.85 (2.30)	6.29 (1.51)	51.05 (7.131) S
Turbidity (NTU)	160.44 (7.14)	56.72 (5.19)	64.64 (35.22) S
TS (mg/l)	1329.83 (37.40)	516.22 (25.73)	61.18 (53.76) S
TSS (mg/l)	706.72 (54.35)	286.77 (25.44)	59.42 (20.99) S
TDS (mg/l)	622.83 (36.67)	229.44 (23.22)	63.16 (27.19) S
pH	8.30 (0.43)	7.69 (0.23)	7.34 (3.730) S
D.O. (mg/l)	1.30 (0.33)	2.26 (0.68)	+73.84 (3.736) S
TKN (mg/l)	28.66 (11.87)	13.45 (7.52)	53.04 (3.246) S
NH_4-N (mg/l)	14.16 (3.07)	6.69 (2.33)	52.75 (6.563) S
COD (mg/l)	132.27 (14.72)	57.03 (9.94)	56.88 (7.152) S
BOD (mg/l)	103.72 (28.50)	54.62 (9.32)	47.33 (5.077) S

NS- Not Significant , **S-** Significant , Sd shown in brackets ( )

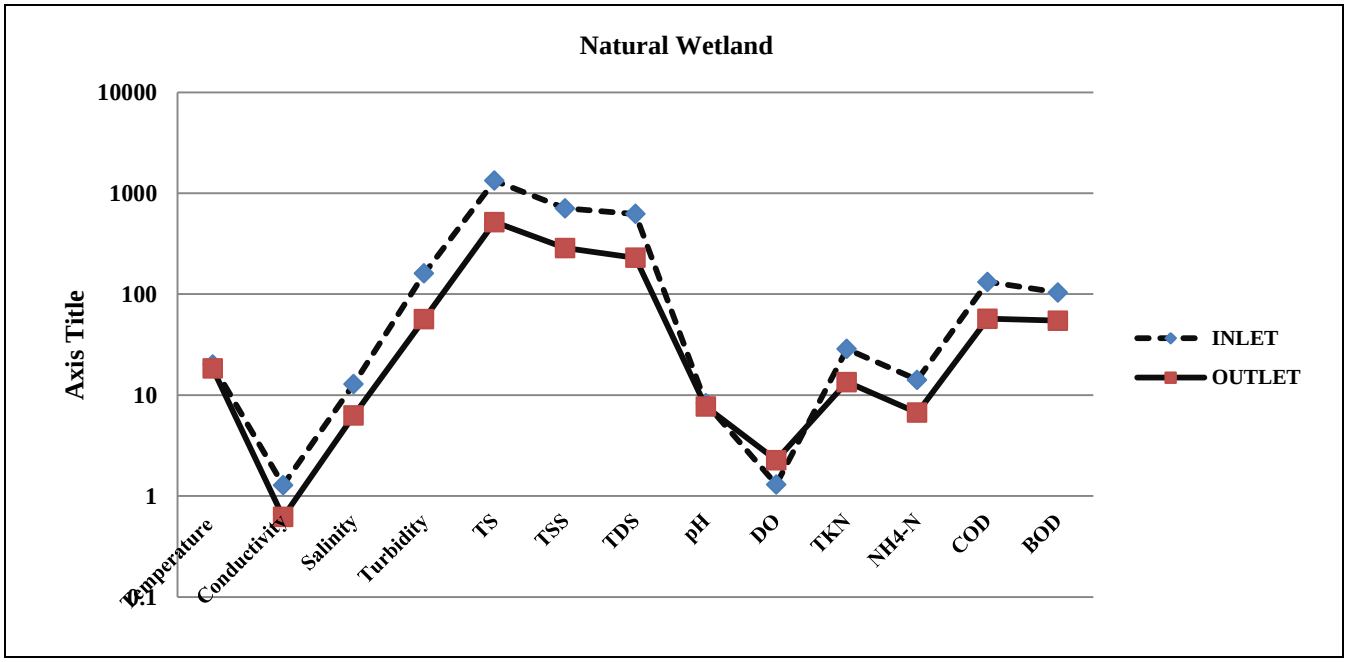

Figure 1- Average values of physical, chemical and biological parameters of Natural wetland treatment system.The data of before and after treatment in domestic wastewater during the study period (June-2008 to May-2010)

V. CONCLUSION AND FUTURE SCOPE

The domestic wastewater in Ujjain city is characterized by high concentration of Total solids, Biochemical Oxygen Demand and Total nitrogen (particularly the NH_4^+-N). At Ujjain the nutrient rich sewage, agricultural runoff and storm water sewerage directly merges into the river *Kshipra*passing through wastewater channel having certain pockets of Natural wetland at MR – 11 Road side in Mahankal Commercial Area, Ujjain of central India.

Wetlands are generally transitional systems lying between the terrestrial uplands and deep open water systems. One of their most important functions is to act as sinks for the nutrients and other chemical compounds entering them with the runoff from their surrounding upland areas and thus protect the adjacent open water systems from rapid degradation .Wetlands are therefore often called as kidneys of the Earth. An array of physical, chemical and biological processes which are linked with and dependent upon each other, are involved in the transformation of nutrients and other substances and the wetland vegetation plays a significant role in these processes. Wetlands are now recognized all over the world as one of the least expensive treatment systems to operate and maintain, because of the natural environmental energies at work in a wetland treatment system. There are currently thousands of natural wetlands worldwide receiving and treating a variety of municipal, industrial and urban runoff wastewater surface flow wetlands have received popularity in northern Europe and USA. The cost effective and similar wetland has been considered as the viable future technology in a developing tropical country like India. Presently almost negligible efforts have been exerted at a community level in developing countries for treating municipal and domestic wastewater. Considering problem of management of waste water in communities and the resultants unhealthy atmosphere, surface flow wetland appears to the most appropriate solution for treatment of wastewater in local colonies.In present research work various pollutants have been removed from domestic wastewater like – Conductivity, Salinity, Turbidity, TS, TKN, $NH4^+$-N, COD and BOD by – 51% , 51%, 64%, 61%, 53%, 52.7%, 56.85, and 47%. The average value of DO was 1.3 mg/l in untreated wastewater and 2.26 mg/l in treated water observed, which indicates 74% increases. The attraction of subsurface systems when compared to free water surface and overland flow system it has in part the perception of decreased risk of nuisance from flies and odor and also has greater efficiency in terms of land usages.

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