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CONSTRUCTED WETLAND FOR LIVESTOCK EFFLUENT TREATMENT USING *PHRAGMITES KARKA*

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***Abstract** – Constructed wetlands, which may be one method of managing agriculture wastewaters are ecologically engineered systems that are akin to natural wetland systems that are built using quantitative approaches, founded on basic ecological principles. Phragmites karka is predominant species used in constructed wetland. The water quality of inlet and outlet of water discharged from livestock effluent to the Vertical Flow Subsurface Constructed Wetland (VFSSCW) it will be treated by roots of Phragmites karka plant. Different physical, chemical and biological parameters were evaluated for the assessment of water quality. Physical parameter such conductivity, salinity were decreases while chemical and biological parameters such as phosphorus total nitrogen BOD also reduced in treated outlet water. Experiments were conducted in the consecutive three season i.e. Rainy (July to October), Winter (November to February) and Summer (March to June) of one year.*

Keywords- Livestock effluent, *Phragmites karka*, Constructed wetlands

I. INTRODUCTION

Water plays an integral role in today's society. It is vital for the health and survival of plants, animals, ecosystems and humans. It is a necessary input of municipal, industrial and agricultural systems. Globally, water is becoming a declining resource as demands increase and quality deteriorates. The decline in water quality can be attributed to pollution entering surface and groundwaters from point and non-point sources such as municipal and industrial discharges, seepage and runoff from the agriculture etc. Each source has its own unique mixture of potential pollutants and varies according to location and site specific circumstances.

India's main occupation is agriculture. Livestock rearing has been an integral part of the agricultural systems in India. Current India possesses the world's largest livestock population. Livestock waste goes under agriculture waste. Agricultural non-point source pollution is one of the main sources of water quality deterioration. 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.

Source of contamination of agricultural wastewaters can vary depending on the farming operations. Wastewaters from livestock farms usually bear an elevated BOD, and total suspended solids as well as a complement of nutrients similar to those of municipal wastewaters (Kadlec and Knight, 1996). Nutrients are commonly found in municipal and agricultural wastewaters (Helgesen *et al*., 1994, Carpenter *et. al.,* 1998). There are three nutrients of major importance: Nitrogen (N), Phosphorus (P) and Potassium(K). In most cases the livestock effluent is generally discharged as such in the untreated form into the nearby water bodies like rivers, lakes etc. where it can cause severe sanitary and other water pollution problems. Among the emergent plants, *Phragmites* species, *Typha* species have been most extensively used in constructed wetland systems worldwide although several other species have been tried in experiments. Therefore Indian species of *Phragmites karka* were tested for their treatment potential for livestock effluent. Most of constructed wetland employed in India have relied on Phragmites as the sole emergent species of interest (Juwarkar *et al.,*1995; Billore *et al.,* 2001; Billore *et al.,* 2002; Billore *et al.,* 2008).

II. MATERIAL AND METHODS

Site description-

for the experiment, 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 as shown in figures 1 and 2.

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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.

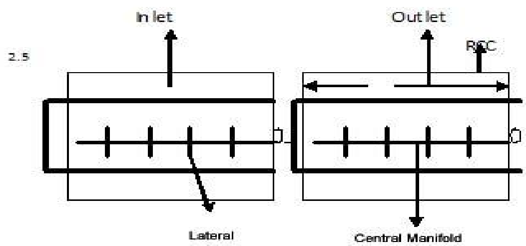

Fig.1 Plain view of VFCW combined in series with inlet and outlet arrangement

Fig. 2 Reed Growth in VFSSCW

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.

Phragmites karka (Reed) was 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. Reed was planted over the surface area of 1.118m^2 with the plant density 6 -12 plant/m^2. VFSSCW design system was designed for retention capacity of 130 liters for about 3 days.

Sample collection-

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 seasonally Rainy (July to October), Winter (November to February) and Summer (March to June) to observe and analyze the different seasonal effect.

Conductivity was directly measured by conductivity meter by immersing the electrode in the water sample. The results were expressed in us/mS.

Salinity was originally conceived as a measure of the mass of dissolved salts in a given mass of solution. For the determination of salinity, one normally uses indirect method involving the measurement of conductivity. For the empirical relationship of salinity and conductivity is expressed as follows-

Salinity = Conductivity x 10

The results of untreated and treated livestock wastewater or salinity measurement have taken in mS/ cm^2. TS, TSS and TDS were estimated according to standard method, APHA, 1998. The results were expressed in mg/l. 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. Results of nitrogen and phosphorus were expressed in mg/l. Biochemical Oxygen Demand (BOD) estimated by modified Winkler's method (APHA,1998). Results were expressed in mg/l.

III. RESULT AND DISCUSSION-

For the analysis of various parameters of untreated and treated livestock effluents in VFSSCW, two sampling points designed in the present investigation.

Table1: Comparison of seasonal variations in different parameter of untreated (Inlet) and treated effluent (Outlet) of Vertical Flow Constructed Wetland (VFSSCW) using of *Phragmites karka* from January 2008 to December 2008 with their % reduction

Parameters	Summer Season			Rainy Season			Winter Season		
	Inlet	Outlet	% reduction	Inlet	Outlet	% reduction	Inlet	Outlet	% reduction
Conductivity	37.18	8.6	76.87	33.48	11.85	64.61	36.27	10.51	71.02
Salinity	371.8	86	76.87	334.8	118.5	64.61	362.7	105.1	71.02
TSS	772.96	136.33	82.36	524.41	172.31	67.14	639.58	164.68	74.25
TDS	2466.86	781.94	68.3	1092.12	488.15	55.3	1520.61	572.05	62.38
TS	3224.92	781.44	75.77	1603.51	568.54	64.54	2158.4	619.87	71.28
Ammonium-N	83.98	11.42	86.4	70.56	22.14	68.62	74.48	18.88	74.65
Nitrate-N	17.08	4.18	75.53	13.52	5.18	61.69	12.74	3.74	70.64
TKN	168.9	20.6	87.8	164.44	31.33	80.95	180.51	31.33	82.64
TP	82.67	30.42	63.2	68.68	36.87	46.32	75.2	29.57	60.68
BOD	13310	3835.5	71.18	10360	4159	59.86	11555	4076.5	64.72

The seasonal variations of conductivity and salinity results are shown by table1. During the summer season the highest reduction was observed followed by winter and rainy seasons. During the summer season these parameter the highest reduction occurred by VFSSCW of Reed grass i.e. 76.87. The seasonal variations of total suspended solids results show that the during summer season the reductions are highest as compare to rainy and winter seasons by Reed bed VFSSCW. In summer season the highest reduction was 82.36% and lowest in rainy 67.14% observed by VFSSCW of *Phragmites karka.* The Total Dissolved Solid reduction from inlet to outlet livestock effluent is observed during summer seasons respectively. The excellent performance occurred by VFSSCW of reed bed. These is the providing aerobic zone around roots and rhizome of *Phragmites karka* (Reed grass), which have enhanced the microbial activities that decompose the soluble and suspended organic matter. The highest TS reduction occurred during the summer season followed by winter and rainy season by Reedbed VFSSCW. During the summer season the average percentage reduction value was 75.77%.

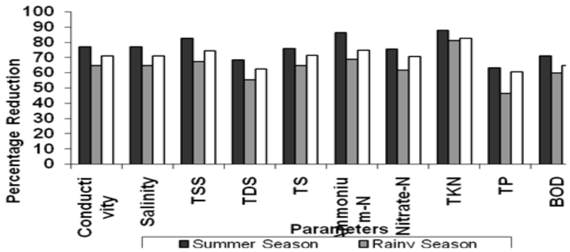

Fig.3: comparative percentage reductions of different parameters from inlet to outlet of Vertical Flow Constructed Wetland (VFSSCW) using of *Phragmites karka* from January 2008 to December 2008.

The seasonal variations of NH_4^+ - N during the summer season reduction 86.4% and in rainy 68.62% recorded by VFSSCW of *Phragmites karka*. Seasonal result of NO_3^- -N are shown by the table during the summer season the reduction is highest as compare to winter and rainy seasons. Seasonal data of TKN results are show that the during summer season the reduction is highest. This reduction was 87.8% observed and lowest in rainy 80.95% by VFSSCW of *Phragmites karka.* These significant reductions in TKN value are considered due to many ongoing biological processes like aerobic and anaerobic denitrification, plant uptakes, volatilization and biofilm immobilization etc. Seasonal data of TP results show that in summer season reduction was 63.20% and lowest in rainy 46.32% observed by in VFSSCW of *Phragmites karka*. The results are found significant. Seasonal data of TP results show that the highest reduction is occurred in summer period as compare to rainy and winter seasons by VFSSCW systems. Seasonal values of BOD result shows that the during summer the reduction is higher followed by winter and rainy seasons by reed bed of VFSSCW. In summer season the reduction was 71.18% and lowest in rainy 59.86% by VFSSCW of *Phragmites karka* observed. Considering physical parameters reduction/change in conductivity, salinity and nondegradable solids is by processes like sedimentation, filtration and adsorption. The conductivity was observed higher in inlet and outlet during summer month due to lower dilution of water having higher concentration of many metals and nutrients. During the whole study, the conductivity and salinity average values reduce to 70.83% in VFSSCW. Conductivity may be relatively inaccurate due to soluble solids affected by rainfall, run-off and evapotranspiration in wetland treatment system.the present results support the earlier findings (Bavor et al.,1988). 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). 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 removal in wetland treatment systems occurs from adsorption, plant absorption, complexation and precipitation (Watson et al., 1989). The average reduction value was 56.7% calculated by VFSSCW of Reedbed. BOD was significantly (at P=0.05level) reduced from untreated inlet to treated outlet by the VFSSCW. These reduction was more during summer season 71.18% than in winter and rainy seasons, because all components of wetlands were more active during high temperature (Sharma, 2000). A colloidal and dissolved form continues to be removed as wastewater comes in contact with attached microbial growth in the system (Reed et al.,1995). VFSSCW can effectively treat high level of BOD and suspended solids the basic treatment mechanisms include sedimentation, chemical precipitation, adsorption and microbial interactions with BOD as well as uptake by vegetation (Wood, 1995). Seasonal effects on BOD removal efficiencies were also evident, the best and most consistent overall performance occurred during the summer months as also reported by earlier workers(Henneck, et al.,2001; Karathanasis et al., 2003).

Constructed wetlands are used for treating various types of wastewater e.g. agricultural / livestock wastewater (Du Bowry and Reaves, 1994; Rivera *et al*., 1997; Hunt *et al*., 2000; Smith *et al*., 2006), domestic wastewater (Cooper *et al*., 1997; Schreijer *et al*., 1997) and for polishing advanced treated wastewater effluents for return to freshwater resources (Gscholobl *et al*., 1998)

Constructed wetland has been shown to be a low cost and effective method of different types of wastewater treatment. As a result, constructed wetland gained popularity for treatment of a wide range of a wastewater. However, no information is known for the use of constructed wetland to treat livestock effluent/wastewater, in India. *Phragmites karka* was tested for their treatment potential for livestock effluent.

IV. CONCLUSION-

The use of constructed wetlands to treat wastewater is relatively new in India. The constructed wetlands can be used as a sustainable technology by clearly defining the objectives and the goal which we want to achieve with proper monitoring of the performance.

The treatment performance of Vertical Subsurface Flow Construted Wetland (VFSSCW) revealed that this low cost and nature based ecotechnology remove solid particles from the livestock effluent and can generate avoidance of nutrient pollution at the receiving end.

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