

A Green Perspective for Developing Countries: Decentralized Waste Water Treatment Using Reed Bed

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ABSTRACT: Waste water/Sewage treatment is a significant challenge in developing countries mainly due to lack of strong legislation to control wastewater/sewage and institutional capacity for integrated planning and management. Increasing urbanization, population explosion, industrialization and anthropogenic activities has exploits and affect the quality and quantity of the water resources. In the recent scenario, water is a scared resource and in many of the developing countries it is not treated properly due lack of infrastructure facility. In this scenario, we have conducted experimental study which represents the importance of small scale decentralized wastewater treatment using reed bed treatment. In developing country, it is indeed required to promote this kind of green technology as it saves natural resources as well as decentralized treatment can be conducted without piped network. For study purpose, Phragmites plants were grown and wastewater/ sewage was treated for educational campus. From the experiment it was found that root zone treatment process (Reed Bed) gives better quality effluent which can be disposed off on land surface or used for irrigation purpose. It also reduces carbon foot print as technology is not consuming any energy whereas it releases oxygen in environment.

KEYWORDS: Waste water, Reed bed technology, Phragmites, Carbon footprint, root zone, GHG emission

I. INTRODUCTION

Haphazard disposal of untreated wastewater from households as well as institutions and industry is causing severe deterioration of water bodies in urban areas in the developing countries. Most cities do not have adequate systems for the collection and treatment of wastewater and this is usually not considered to be a priority for investment. It is estimated that in developing countries, 300 million urban residents, 34% of them in South Asia, have no access to sanitation. Approximately two-thirds of the population in the developing world has no hygienic means of disposing of excreta and an even greater number lack adequate means of disposing of wastewater. This is a major public health risk as it can lead to outbreaks of water borne diseases such as diarrhoea, cholera, and typhoid. Urban sanitation has become a major challenge for municipalities and small towns in India. Most of the urban and semi-urban areas of the country rely on on-site sanitation facilities such as pit latrines; pour flush toilets and septic tanks. As per the latest estimate out of 22,900 MLD of wastewater generated in the country, only about 5900 MLD (26%) is treated before letting out, the

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Vol. 6, Issue 4, April 2017

rest i.e., 17000 MLD is disposed of untreated. Twenty seven cities have only primary treatment facilities and forty-nine have primary and secondary treatment facilities. The level of treatment available in cities with existing treatment plant varies from 2.5% to 89% of the sewage generated. There are 35 metro cities (more than 10 Lac Population) where 15,644 Millions liter Per Day (MLD) of sewage is generated from these metropolitan cities. The treatment capacity exists for 8040 MLD i.e. 51% is treatment capacity is created [1].

The Root Zone technology is a solution to the modern industrialized world's water pollution problems. Reeds are coarse grasses growing in wet places. Reed bed is one of the natural and cheap methods of treating domestic, industrial and agricultural liquid wastes. Reed bed is considered as an effective and reliable secondary and tertiary treatment method where land area is not a major constraint [2]. In this sandy body, reed plants generally with hollow root which bring oxygen into the filter bed are planted. Application of reed bed technology is finding wider acceptability in developing and developed countries, as it appears to offer more economical and ecologically acceptable solution to water pollution management problems. The country's first RZT system was designed by NEERI at Sainik School; Bhubaneshwar, Orissa. It has been reported, that the reed bed treatment gives a very good performance of removing 90% BOD and 63% nitrogen [3].

The objective of this work is to analyze the wastewater generated in the institute campus and evaluate the effectiveness of treated effluents by root zone system. The study, represents reduction in carbon emission due to usage of green technique which lead to reduced carbon footprint at global level. A carbon footprint is historically defined as "the total sets of greenhouse gas emissions caused by an organization, event, product or individual." A carbon footprint is provided as a tool to quantify the life cycle GHG emissions and identify opportunities to reduce climate change impacts. With rapid urbanization and infrastructure investment, wastewater treatment plants (WWTPs) in cities are putting increased pressure on energy consumption and exacerbating greenhouse gas (GHG) emissions.[4]

II. BACK GROUND

On-site wastewater treatment systems can generally be divided into two categories; (i) small scale treatment systems for single houses (1 – 10 population equivalent, PE) and (ii) treatment systems for small communities (10 –500 PE). In recent years significant improvements have been reported in wastewater infrastructure for communities with PE above 500 and 2000 in Ireland and the EU respectively [5]. Implementation of the Urban Waste Water and Water Framework Directives (WFD) has been a key driver in achieving these improvements. While on-site systems can offer economic, societal and environmental benefits there is an increasing awareness of the particular challenges offered by on-site wastewater treatment systems[6]. These challenges include a requirement for robust, cost-effective, low maintenance technologies that can achieve the required levels of treatment [7].

In India, the most common method of disposal of waste water is by land spreading. This treatment method has numerous problems, namely high labour requirements and the potential for eutrophication of surface and ground waters. In this regard's some other alternative have to be introduced like sand filters and wetland, which are economical as well as less process charges. Constructed wetlands for wastewater treatment have substantially developed in the last decades. As an eco-friendly treatment process, constructed wetlands may enable the effective, economical, and ecological treatment of agricultural, industrial, and municipal wastewater. The present study reviews the recent developments in wetland technology for wastewater treatment as well as focus on affect and application[8].

Reed bed system for wastewater treatment has been proven to be effective and sustainable alternative for conventional wastewater treatment technologies. Use of macrophytes to treat wastewater is also categorized in this method. This new approach is based on natural processes for the removal of different aquatic macrophytes such as floating, submerged and emergent. Macrophytes are assumed to be the main biological components of wetlands. These techniques are reported to be cost effective compared to other methods. Various contaminants like total suspended solids, dissolved solids, electrical conductivity, hardness, biochemical oxygen demand, chemical oxygen demand, dissolved oxygen, nitrogen, phosphorous, heavy metals, and other contaminants have been minimized using aquatic microphytes. In this

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paper, role of these plant species, origin and their occurrence, ecological factors and their efficiency in reduction of different water contaminants have been presented [2].

In this study an inventory of operational data was collected from thirty-five wastewater treatment plants in South-East Queensland. Sufficient data was available to perform greenhouse gas calculations from first principles for thirty-three of the plants using a massbalance type approach. Potential fugitive emissions of nitrous oxide and methane were taken into account to the limit of current knowledge. The significance of uncertainties in fugitive emissions as well as the non-biogenic component of organic material in the raw wastewater was highlighted using Monte Carlo simulations for predicting combined probability. The normalised GHG emission results were expressed on a 'tonnes CO₂-equivalent per megalitre' (treated average dry weather flow) basis. Typical results lay in the range approximately 1.0 to 2.5 (overall mean 1.7) tonnes CO₂-e/ML. Combined probability analysis suggested that 5th and 95th percentile values typically lie in the range Mean \pm 20% due to the uncertainties in fugitive emissions and non-biogenic influent organics, but this range could be potentially smaller or larger, depending on the relative dominances of the uncertain emission factors. The potential for long-term carbon sequestration via biosolids disposal is also uncertain. However, the potential for emissions offsets (carbon credits) for WWTPs in this respect appears to be relatively small when taking into account all likely direct and indirect emissions [4].

A constructed wetland having vertical flow bed reed bed system (Gravel /sand) was chosen as a treatment plant for tertiary treatment of domestic waste. The surface of the vertical flow pilot plant amounts to 0.60 m² and depth of bed is about 0.60 m. The application of the conventional plant effluent is carried out in intermittent flushes. Final nitrification and partial de-nitrification and elimination of phosphorus are the main goals to be achieved. In the framework of the present research work the efficiency and operational reliability will be determined by loading the different kind of secondary effluent. Results, of the study indicate that NH₄ -N removal efficiency of 97% to 99%, COD removal efficiency of 50 – 60 % and phosphate removal efficiency of 60 - 73 % can be achieved using the constructed wetland [9].

The waste water generated from the quarters, school hostel and college hostels in our university campus were collected and analyzed. Conventional treatment method and the method of purification using Reed bed for the treatment of effluent were compared. The plant used for this purpose was *Phragmites australis* which is locally known as NANAL. The experiment was conducted with the Primary treated sewage taken from the Sewage Treatment Plant (STP) of our campus. From the experiment it is found that the one with Reed Bed system gives a better quality treated water vis-à-vis the campus STP treated water. Hence, the filter bed of STP is planted with *Phragmites australis* as a trial run. The project presents the method of construction of root zone bed and the effectiveness of removal of various contaminants using this root zone treatment process. The results for raw water and treated water samples were compared and discussed [3].

III .MATERIALS AND METHOD

Material and Methods

A field scale unit of Reed bed system was established at C.K.Pithawalla college of Engineering and Technology, Surat in the state of Gujarat, India. The climate of the region is characterized with summer, monsoon and winter seasons. About 90% (800mm.) of the rainfall occurs during monsoon (June to September). The minimum and maximum temperature varies between 7°C to 43°C.

Construction and working of reed bed: The preliminary study was conducted and for sewage treatment reed bed plant were designed. The size of reed bed channel was 1.0m length x 0.75m breadth and 0.6 m depth. The bottom layer is made impervious than trench is filled with gravel, pebbles, sand and soil. The reed plant grows in the soil. During the growth period of one month, only plain water was sprinkled. Then sewage water was let into the root zone system and the samples were collected to measure effectiveness of treatment. The six sets of study were conducted and detention period were taken 3 and 5 days respectively.

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(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

Functions of phragmites

The process involves the raw effluent (after screening /removing grit or floating material) which is passed horizontally through a bed of soil having impervious bottom. The root zone system creates channels for the water to pass through. The roots introduce oxygen down into the body of soil and provide an environment where aerobic bacteria can thrive. These organisms are necessary for the breakdown of many types of compounds in particular in the oxidation of ammonia to nitrate; in the biological breakdown of nitro compound. The process of nitrification takes place i.e. the plants themselves take up a certain amount of nutrient from the wastewater. The Reed beds can help to achieve a better standard of water quality through

1. High level of bacterial removal
2. Decreased biological oxygen demand
3. Reduction of nitrogen concentrations and removal of metals [3]

Performance evaluation of the system with different Reed Sludge complex parameters: The treatment potential of reed was assessed through various physico-chemical characteristics. The reed bed is designed to optimize the physical, chemical, and biological processes naturally occurring in the system. Wastewater contains a variety of inorganic and organic substances from domestic sources. The wastewater parameters namely BOD, COD, TDS, TSS, alkalinity, chloride and pH were analyzed. The procedures followed for measurement of parameters are the standardised methods [10].

Type of Reed Bed: There are three different types of systems that have been developed during the past 25 years for treating wastewater and sewage effluent. Figure shows horizontal Flow systems. waste water must be pretreated

- **Horizontal flow reed-beds**

especially with respect to suspended solids so as to prevent the clogging of filter media. Filter bed should not be deeper than the depth to which plants roots can grow (30-60 cm), as water tends to flow faster below the dense bed of roots. To prevent percolation of wastewater in ground, the bottom must be sealed. While the top part of the filter media in a planted filter is kept horizontal, constructed bottom slopes down from inlet to outlet preferably

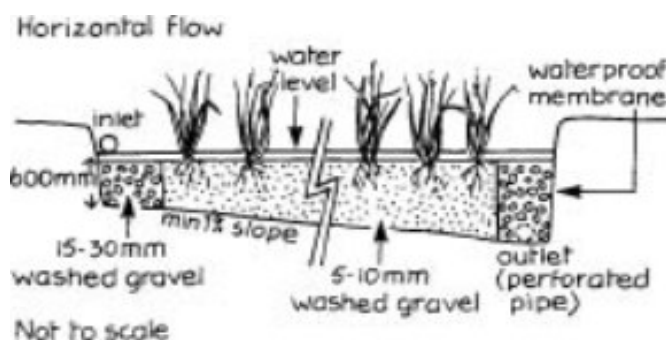


Figure 1. Horizontal Reed bed

by 1%. The bed should be prepared by giving a longitudinal slope of 1 in 40 for free flow of sewage in the soil from inlet to outlet. The treatment can reduce the level of BOD (Biochemical Oxygen Demand), COD and SS (Suspended Solids) in sewage treatment plant effluent. Horizontal flow reed-beds should *only* be considered for tertiary treatment after a full sewage treatment plant or it is used for low strength sewage. A typical application would be to treat the discharge from a slightly undersized package sewage treatment plant which is failing to meet its discharge permit standard for BOD and Suspended Solids.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

IV. RESULTS AND DISCUSSION

Sr. No.	Parameters	Waste water	Treated water 3 days	Treated water 5 days	Treated water			Method of Measurement
					Water	3days	5 days	
1	pH	6.9	7.2	7.1	6.77	7.3	7.3	IS-3025(Part-2):1983(RA-2002)
2	TDS	555	347	232	560	344	227	IS-3025(Part-16):1984(RA-1996)
3	TSS	237	75	41	240	70	40	IS-3025(Part-17):1984(RA-2002)
4	Chloride	65	33	25	50	20	19	IS-3025(Part-32):1988(RA-1999)
5	Alkalinity	192	143	102	184	122	100	IS-3025(Part-23):1986(RA-2003)
6	COD	488	298	125	497	290	150	APHA 5220 – B
7	BOD	255	49	29	245	43	30	IS-3025(Part-44):1993

Table 1. First & second set of result

Sr. No.	Parameters	Waste water	Treated water 3 days	Treated water 5 days	Treated water			Method of Measurement
					Water	3days	5 days	
1	pH	6.7	7.1	7.3	6.9	7.2	7.3	IS-3025(Part-2):1983(RA-2002)
2	TDS	575	350	115	540	331	221	IS-3025(Part-16):1984(RA-1996)
3	TSS	270	65	50	242	65	50	IS-3025(Part-17):1984(RA-2002)
4	Chloride	70	50	24	62	22	19	IS-3025(Part-32):1988(RA-1999)
5	Alkalinity	201	126	102	200	120	90	IS-3025(Part-23):1986(RA-2003)
6	COD	491	280	125	472	287	130	APHA 5220 – B
7	BOD	260	45	30	252	40	35	IS-3025(Part-44):1993

Table 2. Third & fourth set of result

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(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

Sr. No.	Parameters	Waste water	Treated water 3 days	Treated water 5 days	Treated water			Method of Measurement
					Water	3days	5 days	
1	pH	6.9	7.1	7.1	6.7	7.1	7.3	IS-3025(Part-2):1983(RA-2002)
2	TDS	560	330	230	570	352	220	IS-3025(Part-16):1984(RA-1996)
3	TSS	232	75	40	260	58	54	IS-3025(Part-17):1984(RA-2002)
4	Chloride	72	37	26	70	47	22	IS-3025(Part-32):1988(RA-1999)
5	Alkalinity	190	135	100	180	120	112	IS-3025(Part-23):1986(RA-2003)
6	COD	488	280	123	499	293	119	APHA 5220 – B
7	BOD	280	52	29	259	47	32	IS-3025(Part-44):1993

Table 3. Fifth and sixth set of result

The all above table 1,2 & 3 represents characteristics of influent and effluent result obtained after 3 and 5 days for six different set of experiment. The obtained result depict pH of sewage was acidic that turns into neutral range. Significant reduction is observed in TDS, TSS, Chloride, and Alkalinity. Major concern parameters are COD and BOD which are also treated up to its disposal limit. So results obtained are really promising hence this treatment proves efficient for small or decentralised treatment for remote areas having low strength sewage.

Sr NO.	Parameters	Unit	Avg. reading after 3 days	Avg. reading after 5 days	Permissible Range
1	TDS	mg/l	345	210	220-340
2	TSS	mg/l	68	47	30-90
3	Chloride	mg/l	35	23	10-35
4	Alkalinity	mg/l	128	101	100-150
5	COD	mg/l	288	129	100-350
6	BOD	mg/l	46	31	20-50

Table 4. Permissible range of different parameter

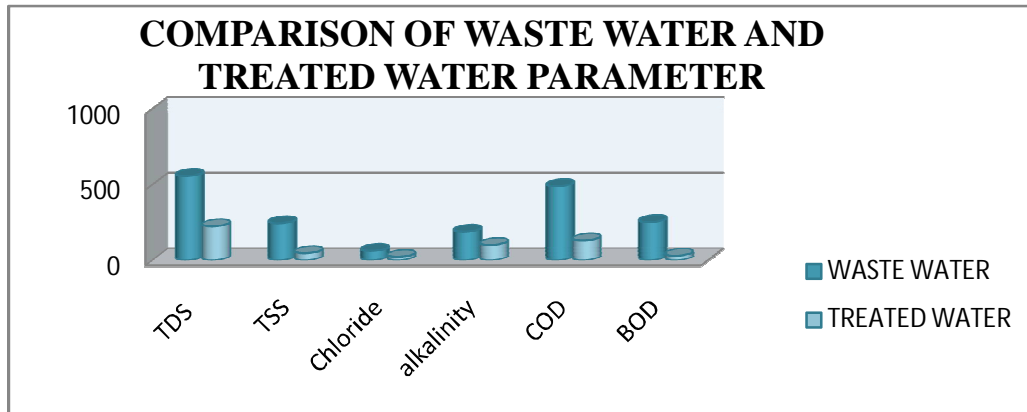


Figure 2. comparison of treated & untreated waste water

The table 4 shows all treated parameters are well within standard limit of as well as figure 2. represents comparison of treated and untreated waste water parameter.

V. CONCLUSION

The treatment of sewage water is always a critical issue for municipal authorities and industrial units having small colonies, remote places where piped network is not available. Hence most of the time, it is left untreated and disposed off. Even when sewage water get treated, traditional treatment process is preferred. The table 5 represents the prime important parameter for treatments of sewage are BOD and COD. The BOD and COD are reduced to 88 and 72 percentage respectively.

It is observed during study that, by adopting reed bed treatment carbon emission is decreased and can be reused for secondary purpose. All the characteristics of treated sewage are within the permissible limits of reuse/disposal of waste water. So, treated sewage can be used for flushing toilets or for washing floors, yards or roads & gardening where potable water quality is not required.

Sr NO.	Parameters	% reduction after 3 days	% reduction after 5 days
1	TDS	38.58	59.47
2	TSS	70.90	83.34
3	Chloride	60.00	62.00
4	Alkalinity	33.70	45.66
5	COD	69.82	71.65
6	BOD	82.45	87.76

Table 5. comparison of percentage reduction in different parameter

International Journal of Innovative Research in Science, Engineering and Technology

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Website: www.ijirset.com

Vol. 6, Issue 4, April 2017

The reed bed demonstrated a greater sludge volume reduction than the conventional bed. The operation and maintenance costs associated with the conventional bed are higher than those associated with the reed bed. The operation and maintenance costs associated with the reed bed were 76.31% lower than those of the conventional bed as no energy is used for treatment.

Reed bed treatment systems are a highly flexible treatment solution to waste water/sewage challenges, which is environmentally-friendly and low maintenance. The Effluent can be used as irrigation and harvested reeds for compost or animal feed, the system is cost effective to build. It requires little effort and money to maintain, it can become an aesthetically pleasing functional part of a property.

Carbon emissions reduction is among the top objectives for corporate environmental management programs. Not only is the environmental impact of greenhouse gases familiar and visible to the public, it carries a high potential for future regulation. In addition, lowering carbon emissions often goes hand-in-hand with energy cost-cutting, which can provide a critical business advantage.

REFERENCES

1. Nazimuddin, "Status of sewage treatment in India" Central pollution control board report, India, 2005
2. Bansari M. Ribadiya, "Treatment of municipal and industrial wastewater by reed bed technology: A Low cost treatment approach" Int. Journal of Engineering Research and Applications, Vol. 4, Issue 12(Part 3), pp.15-18, December 2014
3. Ramprasad. C , "Experimental study on waste water treatment using lab scale reed bed system using Phragmitisaustralis." International journal of environmental sciences Volume 3, No 1, pg 297-304 ,2012
4. David de has, "Energy and greenhouse footprints wastewater treatment plants in south-east queens land". Report of Advanced Water Management Centre, The University of Queensland, St Lucia, Brisbane, QLD 4072,2009
5. EC, 6th commission summary on the implementation of the Urban Waste Water Treatment Directive: European Commission, Brussels.,2011
6. Muga, H.E., and Mihelcic, J.R.. Sustainability of Wastewater Treatment Technologies. Journal of Environmental Management, 88(3): 437 – 447, (2008)
7. Clifford, E., Nielsen, M., Sorensen, K., and Rodgers, M." Nitrogen dynamics and removal in a horizontal flow biofilm reactor for Wastewater treatment". Water Research. 44(13): 3819 – 3828, 2010
8. Ashwanikumar Dubey "Phragmites Australis (Marsh Plant) as wastewater Treatment Material" International Journal of Agricultural Research and Review "Vol. 1(2): pp 048-055, March, 2014.
9. G.Sreenikethan, "Tertiary treatment in a vertical flow reed bed system", Jr. of Industrial Pollution Control 25 (1) pp 1-8, 2009
10. American Public Health Association., Standard Methods for the Examination of Water and wastewater, 18th. Ed. APHA Publication, Washington D.C.(1992),