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Assessment of performance evaluation of reed (Phragmites karka) in constructed reed bed (CRB) system for domestic sludge, Ujjain city

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Abstract- Sludge is crated by modern societies as unavoidable byproducts as population growth, industralization, urbanization, homeowners, modernization, residences, institutions and commercial and industrial establishments. The proper utilization and disposal of domestic sludge is one of the most critical issues facing today.

Performance of reed in a constructed reed bed system (CRBs) for domestic waste was evaluated. Removal efficiency of some physico-chemical parameters (pH, conductivity, organic carbon, organic matter, nitrate-nitrogen (NO_3−N), ammonium nitrogen (NH_4−N), total kzeldhal nitrogen (TKN) and total phosphorus) in domestic waste emanating from residential areas in Ujjain city.

The size of CRBs were 35m length x 25m breadth and 50m depth and 12m diameter cemented tank were used for sludge treatment in the field. The CRBs was composed of a gravel bed supported below on a layer of pubbled, local clay. Initially CRBs was planted with locally grown grass, *Phragmites karka* at the rate of 6 to 8 plants per m^2. Parameters assessed in both the reed bed sludge complex initially and after 15 days. Sludge can be dewatered and converted into biomass and a low-grade compost without chemical addition or energy.

Removal rates of TOC (43-48%), TKN (58-61%), NH_4−N (50%) and NO_3−N as 58% were recorded. The data and results presented in this paper support the notion that CRB sludge treatment systems and the use of reed beds provide an efficient and ecological principle based an effective alternative for domestic sludge treatment.

***Index Terms*-** cemented tank, constructed reed bed, cost effective, domestic sludge, *phragmites karka,* removal efficiency.

I. INTRODUCTION

In recent times, the treatment and disposal of domestic sludge has become a major challenge to the human being, prompting widespread research and development into its possible reuse. To date, most of the research efforts have been done to assess the feasibility of reusing the sludges in the construction and manufacturing industries[1-4].

Currently, some researchers try to find low-cost and environmental solution for septage handle and disposal like co-composting with organic waste, anaerobic digestion, settling ponds, settling/thickening tanks, sludge drying bed, constructed wetland[5-11].

The urban sludge in tropical developing countries are the worst victim of city, basically because of the widening gap between the increasing waste generation and unavailability of commensurating economical resources to address the issue through conventional technologies. Hence, biological machines may prove to be a novel tool for sustainable management of domestic sludge. Constructed Reed bed technology being natural biological systems operating solely on solar energy is low cost and almost negligible operation and maintenance[12-14].

Reed bed technology utilizes the principle of plant uptake for sludge treatment, similar to constructed wetlands for wastewater treatment[15-17]. Reed beds provide sludge dewatering through plant uptake, evapotranspiration, and drainage. Reed beds chemically alter the sludge as the plants use nutrients and minerals in the sludge for growth. The final product is a well-decomposed, stabilized, humus-like residue suitable for land application[18-19].

Sludge applied to reed beds is turned into a compost-like material that can be used as a soil conditioner. Reed beds act to dewater and reduce the organic content of the sludge, reduce the metals concentrations of the sludge, and stabilize the sludge for subsequent disposal. This is the result of the following: first, the reed root system provides oxygen to the sludge, which increases the activity and population of microorganisms that mineralize the sludge; second, the growth of the plants makes use of the nutrients, minerals, and water in the sludge[20]. This paper under reference therefore is an attempt to evaluate the performance efficiency of CRBs with various parameters in domestic sludge.

II. MATERIALS AND METHODS

A field scale unit of Reedbed system was established at Institute of Environment Management and Plant Sciences, Vikram University in the southern area of Ujjain (75o43’ E longitude 23o09’ N latitude, 491m above mean sea level) in the state of Madhya Pradesh, Central India. The climate of the area is characterized with summer, monsoon, post-monsoon and winter seasons/ About 90% of the rainfall occurs during monsoon (mid June to mid September) and normal annual average rainfall 870mm. The average minimum temperature during winter varies between 7ºC to 16ºC. To achieve set objective study was carried out in two parts / phases:

I. Reed sludge bed construction

A. Site selection: Sampling sites were selected for sludge collection was Ravindera Nagar and Mahananda Nagar residential colony. Sludge was collected from these sites and anlaysed for few physico-chemical characteristics following standard protocol[21]. Physical parameters i.e. pH, Density, Moisture content and chemical parameters i.e. nitrogen, phosphorus, organic carbon & matter, C/N ratio were analysed.

B. Design: After preliminary study design were done for sludge treatment. The size of the system were 35m length x 25m breadth and 50m depth and 12m diameter cemented tank were used for sludge treatment in the field. Three sets of design were taken for sludge treatment. One set is control where no sludge was added, in second set Ravindera Nagar sludge was added and in third set Mahananda Nagar sludge was added. In the system bottom layer is filled with gravel, pebbles, sand and soil then sludge was added and reed grows in the sludge.

C. Planting of Reed (Phragmites karka) Propagation – seed / seedling / rhizome / field collected plants. In each design / system reed plants from nursery were transplanted in 15- 20 number 2 month old plants for treatment of sludge.

D. Reed growth: i. Morphology (Root - Rhizome and Shoot length): The reed grass develop an extensive and dense root zone system, which spreads into the gravel beds of constructed wetlands. These plants absorb nutrients from the wetland bed through their root-rhizome system.

ii. Biomass production: It increased tremendously in root zone in both fresh weight and dry weight.

II. Evaluation of performance of the system with different Reed Sludge complex parameters

The treatment potential of reed was assessed through various parameters as studied in physico-chemical characteristics. Emphasis was made on organic carbon, organic matter, nitrate-nitrogen (NO_3−N), ammonium nitrogen (NH_4−N), total kzeldhal nitrogen (TKN) and total phosphorus. Fertility of Reed Sludge Complex was determined with following parameters analysis at 15days interval analysis.

III. RESULT AND DISCUSSION

Reed bed treatment systems are designed to optimize the microbiological, chemical, and physical processes naturally occurring in system. The microorganisms that flourish in these systems can naturally degrade a wide range of organic chemical products into simpler compound. Optimization of sludge management can help reducing sludge handling costs in wastewater treatment plants. Sludge drying reed beds appear as a new and alternative technology which has low energy requirements, reduced operating and maintenance costs, and causes little environmental impact.

Analysis results were presented in table 1 & 2 and fig 1to 10. pH indicate decrease from 7.9 to 6.9 and 8.10 to 7.15 at Mahananda nagar and Ravindera nagar respectively. No seasonal variation observed in pH value. Conductivity and salinity analysis depict that significant decrease occurred after treatment. It reduces from 1.25 to 0.55mMho in Mahananda nagar sludge followed by Ravindera nagar sludge i.e. 1.30 to 0.60 mMho. Progressive organic matter removal and sludge stabilization in the beds was also observed. Organic carbon and matter reduces 44% in Ravindera nagar sludge while in Mahananda nagar sludge it was 26% only. This may be due to absorption of organic carbon by reed plants for growth and development. Total nitrogen as well as other form of it decreases in sludge treatment. More reduction in total nitrogen in Mahananda nagar sludge followed by Ravindera nagar sludge. Phosphorus content also decreases in both experimental set up.

Constructed reed bed system (CRBs) typically require few months for growth of vegetation, biofilm establishment and sizeable time for development of litter and standing dead compartments[1]. In the present study the root zone unit was established with 2 months old saplings of *Phragmites karka (*local reed grass) planted in the gravel bed with a density of six plants/m^2 covered the entire area within a period of three months. The availability of ample nutrients in the domestic sludge through the constructed reed bed system (CRBs) and tropical warm climate favors the growth of plants.

Nutrient removal during plant growing season averaged 60% for total nitrogen, 53% for Kjeldahl nitrogen, 73% for total phosphorus and 64% for organic matter. Removal remains acceptable in winter despite a slight decrease in efficiency. *Finally,* it should be remembered that Reed Beds are an effective, low-tech form of bioremediation for the treatment of municipal and others sludge. Reed Bed Technology is an effective process using plant life to help in the necessary process of treating some of the byproducts of human communities[22].

IV. CONCLUSION

The purpose of this demonstration was to evaluate the effectiveness of a reed-bed sludge treatment system. Reed beds are capable of dewatering sludge to the same degree as a conventional sludge drying bed with several advantages. These include the ability to reduce the organic content and metals concentration of the sludge, and to stabilize the volatile elements of the sludge at a less expensive cost, compared to conventional treatment.

Reed bed technology involves the application of domestic sludge to beds that have been planted with a specialized species of reeds, in this case, *Phragmites communis*. Similar to constructed wetlands for wastewater treatment, reed bed technology uses plant uptake, in addition to evapo-transpiration, microbial decomposition, and drainage, to stabilize and dewater the sludge. Sludge applied to reed beds is turned into a compost-like material that can be used as a soil conditioner. Reed beds act to dewater and reduce the organic content of the sludge, reduce the metals concentrations of the sludge, and stabilize the sludge for subsequent disposal. This is the result of the following: first, the reed root system provides oxygen to the sludge, which increases the activity and population of microorganisms that mineralize the sludge; second, the growth of the plants makes use of the nutrients, minerals, and water in the sludge. They are simple to operate, without chemical additives or complex electronic controls, and are very low maintenance. Consequently, the energy and operational requirements of reed beds are very low.

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Table -1. Physico-chemical characteristic of Reed Bed sample analysis in domestic sludge of Mahananda nagar

S.No.	Parameters	Initial	15d	30d	45d	60d
1	pH	7.90	7.70	7.50	7.40	7.20
2	Conductivity	1.25	1.20	1.00	0.80	0.55
3	Salinity	12.50	12.00	10.00	8.00	5.50
4	% OC	38.00	37.00	33.00	30.00	28.00
5	%OM	65.51	63.79	56.89	51.72	48.27
6	% Moisture content	70.00	58.00	35.00	22.00	11.00
7	Bulk density	1.75	1.71	1.62	1.53	1.41
8	TKN	37.10	35.70	25.90	20.60	12.17
9	NO_3-N_2	2.96	2.85	2.16	1.95	1.72
10	NH_4-N	41.00	39.20	28.60	19.80	11.20
11	Org.-N	22.40	20.60	15.40	9.62	5.14
12	Av.P	6.40	5.90	4.10	3.50	2.70
13	TP	7.70	7.50	5.60	3.10	1.20

Table -2. Physico-chemical characteristic of Reed Bed sample analysis in domestic sludge of Ravindra nagar

S.No.	Parameters	Initial	15d	30d	45d	60d
1	pH	8.10	7.90	7.70	7.60	7.40
2	Conductivity	1.30	1.20	1.00	0.75	0.60
3	Salinity	13.00	12.00	10.00	7.50	6.00
4	% OC	42.50	41.40	38.50	30.10	23.70
5	%OM	73.27	71.37	66.37	51.89	40.86
6	% Moisture content	80.00	71.00	58.00	35.00	14.00
7	Bulk density	1.95	1.90	1.65	1.32	0.90
8	TKN	40.60	39.90	33.10	21.00	15.00
9	NO_3-N_2	3.50	3.30	2.90	2.20	1.90
10	NH_4-N	42.70	41.30	34.80	24.90	13.20
11	Org.-N	24.60	22.90	15.80	10.10	4.60
12	Av.P	6.80	6.60	5.10	4.30	2.70
13	TP	7.50	7.20	5.10	2.50	1.00

Note: TKN : Total Kzeldhal Nitrogen, TP : Total Phosphorus.

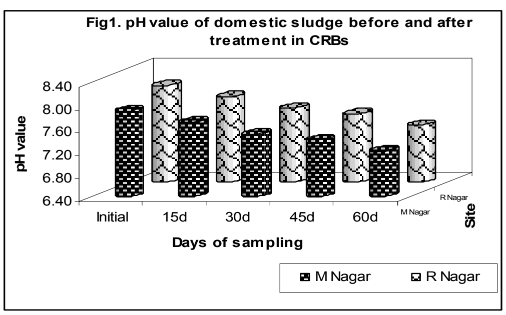

Fig1. pH value of domestic sludge before and after treatment in CRBs

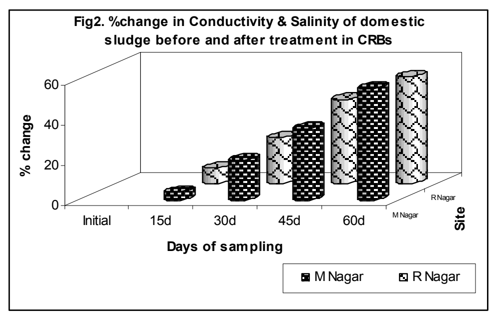

Fig2. %change in Conductivity & Salinity of domestic sludge before and after treatment in CRBs

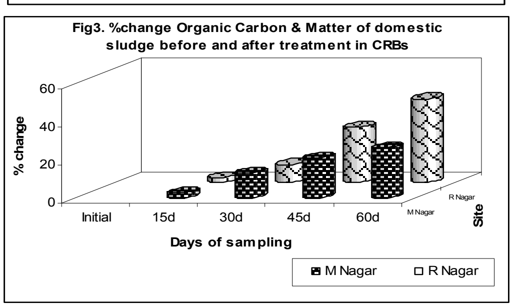

Fig3. %change Organic Carbon & Matter of domestic sludge before and after treatment in CRBs

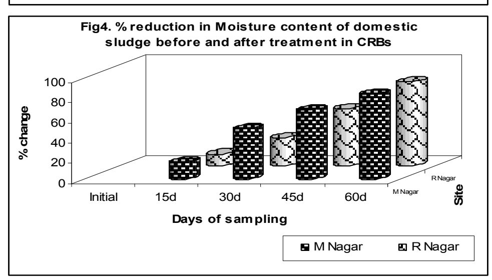

Fig4. % reduction in Moisture content of domestic sludge before and after treatment in CRBs

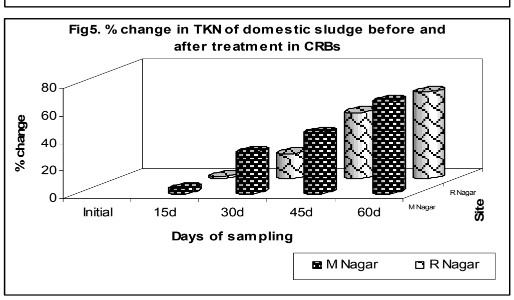

Fig5. % change in TKN of domestic sludge before and after treatment in CRBs

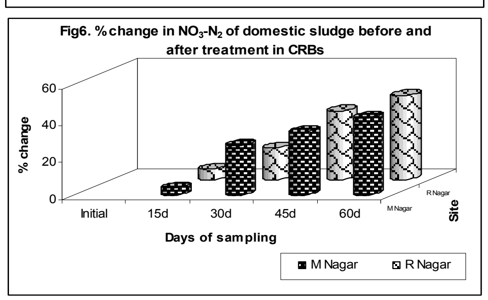

Fig6. %change in NO_3-N_2 of domestic sludge before and after treatment in CRBs

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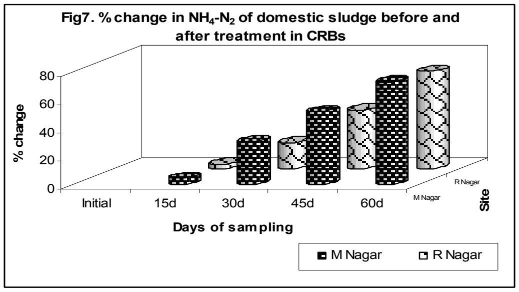

Fig7. % change in NH_4-N_2 of domestic sludge before and after treatment in CRBs

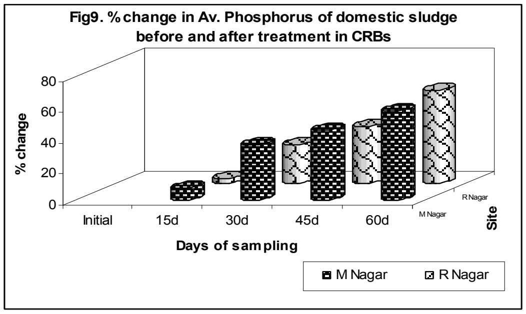

Fig9. % change in Av. Phosphorus of domestic sludge before and after treatment in CRBs

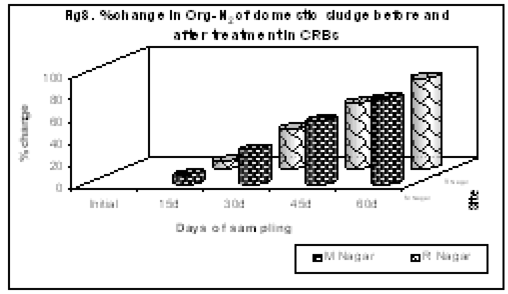

Fig8. % change in Org-N_2 of domestic sludge before and after treatment in CRBs

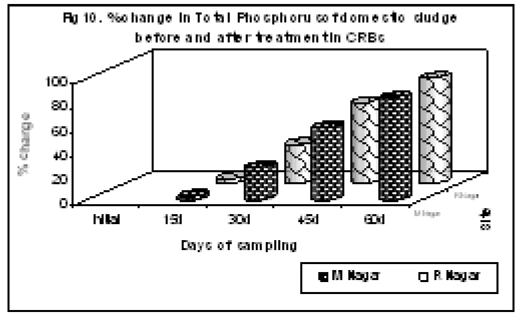

Fig 10. % change in Total Phosphorus of domestic sludge before and after treatment in CRBs

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