International Journal of
Research in Chemistry and Environment
Available online at: www.ijrce.org
ISSN 2248-9649

Research Paper

Treatment of Municipal Wastewater through Constructed Wetland

***Anwar Tahseen[1], Singh Bihari[2], Kumar Rakesh[3]**
[1]P.G Department of Environmental Sciences, A. N College, Patna-800001, INDIA
[2]P.G Department of Environmental Sciences, A. N College, Patna-800001, INDIA
[3]NEERI-CSIR, Mumbai Zonal Centre, Mumbai-400018, INDIA

(Received 26th March 2015, Accepted 18th June 2015)

Abstract: *Constructed wetlands are artificial wastewater treatment system of shallow experimental tanks, ponds or channels that are planted with locally available wetland plants. They work on natural capacity of plants to treat wastewater from different sources. In view of rising concern about pollution of water bodies due to discharge of waste in them, it is necessary to initiate alternative thinking as conventional methods through STPs (Sewage treatment Plants) have had limited success. In recent years the application of specifically designed wetland based technology (popularly known as Phytorid technology) for treatment of wastewater- municipal, urban and agricultural, is becoming widely acceptable. The technology has been found to be very effective in water pollution control as it functions as water 'pollutant sinks' for sediments, nutrients and metals. It treats the wastewater in natural manner without the use of chemicals. In short, Phytorid technology is an improved wetland system for treatment of wastewater. The present research work was undertaken by our team on a constructed wetland designed and developed at A. N. College, Patna which is location specific. It has locally available wetland plants which are economically and spatially feasible for wetland study in and around Patna, the capital city of Bihar (India) and for those regions of state which have similar climatic conditions. The main objective of present research work is to provide and popularize a simple, feasible, practically sound, ecofriendly and cost effective technology for wastewater treatment and its reuse in the state of Bihar (India).*

Keywords: Constructed wetland, Wastewater treatment, locally available wetland plants, Phytorid technology.

Introduction

Indian cities and their suburbs contribute immensely to the deterioration of water quality of nearby water bodies mainly because of the population explosion, industrialization and changing lifestyle of urban people. Many of the cities have been provided with wastewater treatment systems but municipalities have not been able to maintain and run the system properly leading to deterioration of nearby water bodies used as a sink for wastewater of the towns and cities. More recently, it has been estimated that most of the developing countries will run out of water by 2050. This is a cause of concern not only for the communities but also a challenge to scientists to find more effective ways of wastewater recycling[1]. Demand for fresh water may be reduced through implementation of simple, easily acceptable and low cost technologies for wastewater treatment and use. Conventional methods of wastewater treatment particularly in urban areas is constrained by availability of space and infrastructure and therefore constructed wetlands are natural alternative to technical methods of wastewater treatment[2]. Constructed wetland's efficiency and potential application in wastewater treatment has been reported by many team of researchers in recent past[3-10]. Though most constructed wetlands around the world have initially been used primarily to treat domestic and municipal wastewater treatment such as agricultural and industrial wastewater, various runoff waters and landfill leachates have recently been taken up successfully and becoming popular[11]. Their simplicity and scalability make them effective for treatment of waste from small communities. If constructed on suitable topography they require little energy input which makes them suitable for those remote rural and semi urban areas where power supply is irregular and insufficient. However, despite the suitability of climate in developing countries, the spread of wetlands in such areas has been described as 'depressingly slow'[12]. The role of *Canna* in wastewater treatment is well documented. However, such study with other locally available wetland plants in and around Patna (India) for the possible application in the treatment of municipal wastewater has not been done. The main objective of the present research work is to provide and popularise a simple, feasible, practically sound, eco-friendly and cost effective technology for wastewater treatment and its reuse in the state of Bihar (India), through this kind of pilot projects in A. N. College, Patna and a few other places of the state.

Material and Methods

A. Description of constructed wetland in A. N. College, Patna premises:

The system comprises of a sequence of three independent chambers (cells). They are

- **Primary Settling Chamber:** In this chamber municipal wastewater collected from nearby sewer is stored and sedimentation process is allowed to take place.
- **Secondary Advanced Filter Chamber:** It consists of pebbles of different sizes arranged in the form of layers through which municipal wastewater is allowed to pass. This acts like a natural filter. It consists of pebbles that allow the passage of water through it.
- **Tertiary Biological Wetland Chambers:** It has a series of two interconnected small chambers consisting of layer of pebbles and planted respectively with *Canna indica* in the first chamber and *Colacasia* in the second chamber.
- **Collection Chamber:** In this chamber treated wastewater is collected. Treated water is re-used for watering the gardens located nearer to the constructed wetland system in the college premises.

The removal of pollutants are through a combination of physical, chemical and biological process including sedimentation, precipitation, adsorption to gravels, assimilation by the plant tissue and microbial transformations.

B. In the present study the municipal wastewater was allowed to enter the constructed wetland system at the flow rate of 80 litre per day. The growth of the plants was observed by measuring the increase in length of shoots at specified time interval. The water samples (i) at the inlet point (ii) at the outlet point of *Canna* chamber and at the final outlet point were analysed by standard methods recommended by APHA[13] to determine different physico-chemical parameters.

Results and Discussion

Analysis of wastewater and treated water samples were done twice during a period of one and half months.

The results of the experiment have been compiled in Table 1 and Table 2.

(i) First date of collection of water samples: 26.02.2015

(ii) Second date of collection of water samples: 12.04.2015

The results of the experiment were recorded in different sets of the study with varying flow rate and retention time.

S. No	Flow rate	Retention time
Set 1	100 litre/day	(A) 12 hrs (B) 24 hrs
Set 2	80 litre/day	(A) 12 hrs (B) 24 hrs
Set 3	60 litre/day	(A) 12 hrs (B) 24 hrs

Data for the sample collected on 26.02.2015

Set 1

Flow rate =100 ltr/day

Retention time A) 12hrs

B) 24hrs

Table 1A: (Retention time 12 hrs)

Parameters	Value at the Inlet point	After Passing through *Canna* Chamber	After Passing *Colacasia* Chamber
Turbidity (NTU)	12.5	2.0	1.7
COD (mg/L)	250	48	46.5
BOD (mg/l)	50	28	26
TS (mg/l)	2560	278	275
TSS (mg/l)	240	28	27
Phosphate (mg/l)	6	1.3	1.3
Nitrate (mg/l)	45	8.0	7.48

Table 1B (Retention time 24 hrs)

Parameters	Value at the Inlet point	After Passing through *Canna* Chamber	After Passing through *Colacasia*
Turbidity (NTU)	12.5	1.6	1.5
COD (mg/L)	250	46	45
BOD (mg/l)	50	25	24
TS (mg/l)	2560	277	275
TSS (mg/l)	240	27	26.5
Phosphate (mg/l)	6	1.2	1.1
Nitrate (mg/l)	45	7.3	6.9

Set 2

Flow rate = 80 ltr /day
Retention time C) 12hrs
D) 24 hrs

Table 1C (Retention time 12hrs)

Parameters	Value at the Inlet point	After Passing through *Canna* Chamber	After Passing through *Colacasia* Chamber
Turbidity (NTU)	12.5	1.5	1.4
COD (mg/L)	250	39	38
BOD (mg/l)	50	21	19
TS (mg/l)	2560	259	253
TSS (mg/l)	240	25	20
Phosphate (mg/l)	6	1.1	0.9
Nitrate (mg/l)	45	7.0	6.49

Table 1D (Retention time 24 hrs)

Parameters	Value at the Inlet point	After Passing through *Canna* Chamber	After Passing through *Colacasia* Chamber
Turbidity (NTU)	12.5	1.3	0.95
COD (mg/L)	260	38	37
BOD (mg/l)	50	20	19
TS (mg/l)	2560	259	254
TSS (mg/l)	240	24	21
Phosphate (mg/l)	6	1.0	0.8
Nitrate (mg/l)	45	6.5	5.89

Set 3

Flow rate = 60 ltr/day
Retention time E) 12hrs
F) 24hrs

Table 1E (Retention time 12 hrs)

Parameters	Value at the Inlet point	After Passing through *Canna* Chamber	After Passing through *Colacasia* Chamber
Turbidity (NTU)	12.5	1.4	1.3
COD (mg/L)	250	38	37
BOD (mg/l)	50	20	19
TS (mg/l)	2560	258	252
TSS (mg/l)	240	24	20
Phosphate (mg/l)	6	1.0	0.8
Nitrate (mg/l)	45	6.74	6.35

Table 1F (Retention time 24 hrs)

Parameters	Value at the Inlet point	After Passing through *Canna* Chamber	After Passing through *Colacasia* Chamber
Turbidity (NTU)	12.5	1.2	0.9
COD (mg/L)	250	36	33
BOD (mg/l)	50	19	16
TS (mg/l)	2560	254	252
TSS (mg/l)	240	21	19
Phosphate (mg/l)	6	0.9	0.75
Nitrate (mg/l)	45	6.43	5.73

Data for the sample collected on 12.04.2015

Set 1

Flow rate =100 ltr/day
Retention time A) 12hrs
B) 24hrs

Table 2A (Retention time 12 hours)

Parameters	Value at the Inlet point	After Passing through *Canna* Chamber	After Passing through *Colacasia* Chamber
Turbidity (NTU)	12	1.8	1.6
COD (mg/L)	250	47	45
BOD (mg/l)	48	27	26
TS (mg/l)	2540	256	255
TSS (mg/l)	220	26	25
Phosphate (mg/l)	6	1.2	1.2
Nitrate (mg/l)	45.2	6.6	6.23

Table 2B (Retention time 24 hours)

Parameters	Value at the Inlet point	After Passing through *Canna* Chamber	After Passing through *Colacasia* Chamber
Turbidity (NTU)	12	1.5	1.4
COD (mg/L)	250	44	42
BOD (mg/l)	48	24	23
TS (mg/l)	2540	254	253
TSS (mg/l)	220	25	24
Phosphate (mg/l)	6	1.1	1.0
Nitrate (mg/l)	45.2	6.34	6.18

Set 2

Flow rate = 80 ltr/day
Retention time C) 12hrs
D) 24hrs

Table 2C (Retention time 12 hours)

Parameters	Value at the Inlet point	After Passing through *Canna* Chamber	After Passing through *Colacasia* Chamber
Turbidity (NTU)	12	0.97	0.85
COD (mg/L)	250	37	35
BOD (mg/l)	48	20	18
TS (mg/l)	2540	250	248
TSS (mg/l)	220	19.5	17
Phosphate (mg/l)	6	0.85	0.72
Nitrate (mg/l)	45.2	5.56	5.29

Table 2D (Retention time 24 hours)

Parameters	**Value at the Inlet point**	**After Passing through *Canna* Chamber**	**After Passing through *Colacasia* Chamber**
Turbidity (NTU)	12	0.95	0.8
COD (mg/L)	250	35	30
BOD (mg/l)	48	18	17
TS (mg/l)	2540	239	219
TSS (mg/l)	220	15	12
Phosphate (mg/l)	6	0.79	0.54
Nitrate (mg/l)	45.2	5.2	4.98

Set 3

Flow rate = 60 ltr/day
Retention time E) 12hrs
F) 24hrs

Table 2E (Retention time 12 hours)

Parameters	**Value at the Inlet point**	**After Passing through *Canna* Chamber**	**After Passing through *Colacasia* Chamber**
Turbidity (NTU)	12	0.9	0.8
COD (mg/L)	250	36	34
BOD (mg/l)	48	19	18
TS (mg/l)	2540	249	247
TSS (mg/l)	220	19	16
Phosphate (mg/l)	6	0.75	0.6
Nitrate (mg/l)	45.2	5.42	5.21

Table 2F (Retention time 24 hours)

Parameters	**Value at the Inlet point**	**After Passing through *Canna* Chamber**	**After Passing through *Colacasia* Chamber**
Turbidity (NTU)	12	0.85	0.7
COD (mg/L)	250	34	29
BOD (mg/l)	48	17	14
TS (mg/l)	2540	239	218
TSS (mg/l)	220	14	11
Phosphate (mg/l)	6	0.73	0.47
Nitrate (mg/l)	45.2	5.0	4.78

C. Effect of Municipal Wastewater on the Growth of Wetland plants:
On every 7th day after the experiment was started, the growth of the plants were recorded by measuring the increase in length of shoots. The results have been shown graphically in Figures 1 and 2.

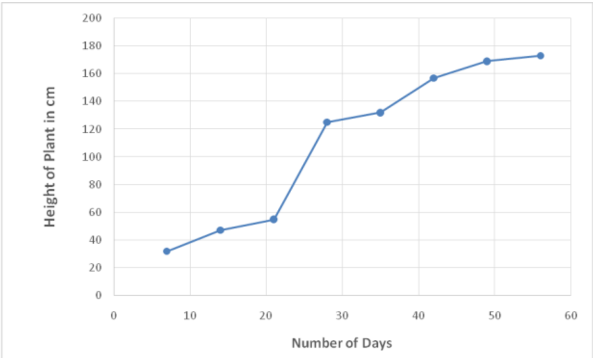

Figure 1: Growth of *Canna* with time (in days)

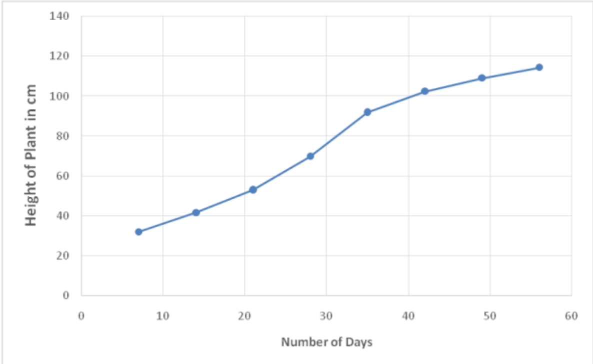

Figure 2: Growth of *Colacasia* with time (in days)

Discussion

• A perusal of Tables 1 and 2 reveals that there has been considerable reduction in the value of all the studied parameters- Turbidity, Chemical Oxygen Demand, Biological Oxygen Demand, Total Solids, Total Suspended Solids, Phosphate and Nitrate of sewer water after passing through the constructed wetland. Most of the values which were high (being much higher than the maximum permissible limit) have been reduced to permissible limits, now suitable for use of the treated water for gardening, cleaning, flushing purposes etc.

- Another important observation which need be mentioned is that the efficiency of the constructed wetland to treat sewer wastewater was found to be reasonably high for the samples collected on 12.04.2015 which was almost one and half months after the wastewater were collected first on 26.02.2015. This is probably because of further growth of root system and maturity of the wetland plants with the passage of time. Similar results have been found in numerous studies by CSIR-NEERI scientists*.
- It may be concluded that optimum efficiency of the constructed wetland to treat sewer water is at the flow rate of 80 litres per day with 24 hours retention time. The efficiency with flow rate 60 litres per day and retention time 24 hours is almost the same as that of flow rate 80 litre per day and retention time 24 hours.

Conclusion

The studied wetland plants can reduce the level of Turbidity, COD, BOD, TS, TSS, Phosphate and Nitrate to different degree in waste water. The systems with *Canna* can more successfully reduce the aggregate organic compounds than *Colacasia* used in the study. Since the technology is low cost, environmentally friendly and simple, the use of constructed wetland in municipal wastewater treatment is a promising technology which could be adopted by the developing countries where limited resources are available for the installation of high tech treatment plants.

Acknowledgement

The research team members extend their sincere thanks to M/S Aaknanda Technologies Pvt. Ltd., Mumbai for providing financial support for the construction of wetland in the A. N College, Patna premises for the present study. The research scholar Mr. Tahseen Anwar is thankful to UGC, New Delhi for providing fellowship.

References

1.Mthembu M.S., Odinga C.A., Swalaha F.M. and Bux F., Constructed wetlands: A future alternative wastewater treatment technology, **12(29)**, 4542-4553 (**2013**)

2. Stottmeister U., Wiebner. A., Kuschk. P., Kappelmeyar U., Kastner M., Bederski O., Muller R. A., Moormann H., Effects of plants and Microorganisms in constructed wetlands for wastewater treatment, *Biotechnol. Adv.,* **22**, 93-117 (**2003**)

3. Karodpati S.M., Kote A.S., Energy efficiency and cost-effective sewage treatment using phytorid technology, *Int. J. of Adv. Technol. and Civil Eng.*, **2(1),** 69-72 **(2013)**

4. Tandon S., Badrike H., Kakde U. and Kumar R., Enhancement in Phytoremediation of Municipal Wastewater by Genetically modifying Wetland and Non-wetland plant species (non-edible), *Global Journal of Bio-science & Biotechnology*, **3(4)** (**2013**)

5. Kadlec R.H, Knight R.L, Vymazal. J, Brix H., Cooper P. and Haberl R., Constructed Wetlands for Pollution Control: Processes, Performance (**2000**)

6. Vymazal J., Brix. H., Coopper P.F., Green M.B. and Haberl R., Constructed Wetlands for Wastewater Treatment in Europe, Backhuys Publishers, Leideen, 366 (**1998**)

7. Tandon S., Inarkar M. and Kumar R., Wetland Treatment of Wastewater from a Milk Processing Unit using *Bambusa vulgaris, Typhalatifolia, Cyperusrotundus, J. Environ Sci.*, **52(1)**, 23-26 (**2010**)

8. Beutel M.W., Water quality in a surface flow constructed treatment wetland polishing tertiary effluent from a municipal wastewater treatment plant, *Water Sci. Technol.*, **66(9)**, 1997-83 (**2012**)

9. Cooper P., The Constructed Wetland Association UK database of constructed wetland systems, *Water Sci. Technol.*, **56(3)**, 1-6 (**2007**)

10. Constructed wetland for wastewater treatment: five decades of experience, *Environ. Sci. Technol.,* **45(1)**, 61-69 (**2011**)

11. Wallace R.H., Wallace S.D., Treatment Wetlands, 2nd edition. CRC Press, Boca Raton, Florida, in press (**2008**)

12. Denny P. et al., Constructed wetlands in developing countries, *Water Sci. and Tech.*, **35(5)**, 167-174 (**1997**)

13. A.P.H.A. Standard method for the Examination of Water and Waste Water. American Public Health Association, Washington D.C. (21stedn.) (**2005**)