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ORIGINAL ARTICLE

Wastewater Treatment through Modified multi-layered Artificial wetland using agrowaste

Beena Kumari, K.S*
Department of chemistry, All Saints' College, Thiruvananthapuram, Kerala INDIA-695007
Email: beenagireesh@yahoo.co.uk

ABSTRACT

The importance of wetlands has changed over time. Wetlands serve as transition zones between aquatic and terrestrial environments and provide a dynamic link between them. The absorptive capacity of a natural wetland is the mechanism employed in a constructed wetland for the purpose of treating wastewater from businesses and municipalities. Constructed wetlands are locating between the wastewater source and aquatic resources. These systems require no maintenance and consume no electricity. The aim of this study is to rejuvenate the polluted water to get pure and useful water by using natural materials. In this study a new method for domestic wastewater treatment through modified multi-layer artificial wetland was conducted. The system was modified by replacing vegetation by layering the top portion with agro-wastes. The cellulose based fibrous materials present in the agro waste helped in waste water treatment process.

Keywords: *Wetlands, Water pollution, Agrowastes, Cellulose fibers, Phytoremediation*

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INTRODUCTION

Only one percent of water on earth is available to humans as fresh water. Thus humanity depends on a very small stock of water for its sustenance. With the increasing population and industrialization, sustainable supply of this resource is in danger due to lack of proper management. This situation gives a clarion call for taking up integrated plans for water utilization and conservation for every agro-ecological area to meet the increase in demands of irrigation, water harvesting, human and livestock consumption, expanding industry, fuel and hydro-electric power generation. Water pollution is the contamination of water bodies (e.g. lakes, rivers, ponds, oceans, aquifers and groundwater) and this occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds. Wetlands are areas of land where water is available in large percentage. Most of the wetlands contain freshwater, while some are brackish and others are truly marine. They can be either permanent or temporary and natural or artificial. Wetlands have the capacity to retain excess floodwater during heavy rainfall that would otherwise cause flooding. By retaining flood flows, they maintain a constant flow regime downstream, preserving water quality and increasing biological productivity for both aquatic life as well as human communities of the region. Previous studies [17, 27] showed that the extent of ground water recharge depends on many factors like the soil and its permeability, vegetation, sediment accumulation in the lakebed, surface area to volume ratio, and water table gradient. A constructed wetland is an artificial wetland created for the purpose of treating anthropogenic discharges such as municipal or industrial wastewater, or storm water runoff [10]. The artificial wetland comprises of such groundmasses as break stone and gravel etc., as well as aquatic plants attached to it. When waste water flows through the groundmass in the wetland, the nutritive materials in water decompose and its absorption by plant or microbial conversion will take place [5]. The artificial wetlands will act as natural filters [19]. Such constructed wetlands use different species of plants that are commonly abound in natural wetlands like cattails, water lilies and rushes etc. This phytoremediation is a low cost method using solar energy [24]. Treatment systems using aquatic plants consist of shallow reservoirs containing floating or submerged aquatic plants. Submerged plants cannot withstand due to high turbidity which will affect their photosynthetic parts [8]. Use of aquatic plants like *Azolla*, Lemna etc. can function as oxygenators also [25-28, 12, 18, 3, 7]. Studies showed that use of cellulose nanomaterials [2, 1, 3] had very good effect on waste water treatment. Studies used agro-waste like pineapple leaves for domestic wastewater treatment [9, 2]. Haider *et al.* [14] examined a variety of adsorbents in his studies and discussed mechanisms, modification methods, recovery and regeneration, and commercial applications. Etim, *et al.* [10] described in his study how agro-waste like coconut coir dust and coconut husk fiber makes in action on domestic wastewater treatment. Low cost activated carbons derived from agricultural byproducts used as layers in domestic multilayer artificial wetland systems [21, 23, 15]. There are studies which gave brief description on the importance and effectiveness on treating domestic wastewater by introducing agro-waste like plantain fiber, coconut fiber, banana stem juice etc. [23, 6, 12, 13, 20]. This study mainly focused on use of low cost, easily available and ecofriendly plant materials for the preparation of artificial wetland and its use for waste water treatment.

MATERIAL AND METHODS

Sample collection

The sample of water was collected from a canal near Ardhanareeswara temple, Menamkulam, Kazhakoottam, Trivandrum district, which has an intrusion of the pollutant river Parvathy puthanar. Analysis of various physical, chemical and biological parameters was conducted. Figure 1 is the image of the site from which the water sample was collected.

Fig1: Canal near Ardhanareeswara temple, Menamkulam,Thiruvananthapuram, Kerala

The water sample was then allowed to pass through an inlet made on top side of the mud garden pot, which is taken as the basic experimental apparatus.

Preparation of model for artificial wetland

A garden mud pot containing two outlets was taken. A cloth was kept inside covering the base of the pot. This was a four layered artificial wetland setup. The bottom most layer (layer 4) was filled with charcoal. A layer of sand was filled above the charcoal layer (layer 3). Above layer 3, layer 2 layer was filled with gravel. The topmost layer (layer 1) was filled with agro-wastes like pineapple leaves, plantain fibre and coconut husk fibre seperately, and in combined manner to study their effectiveness in the treatment process. Different layers used in this method are shown in Figure 2.

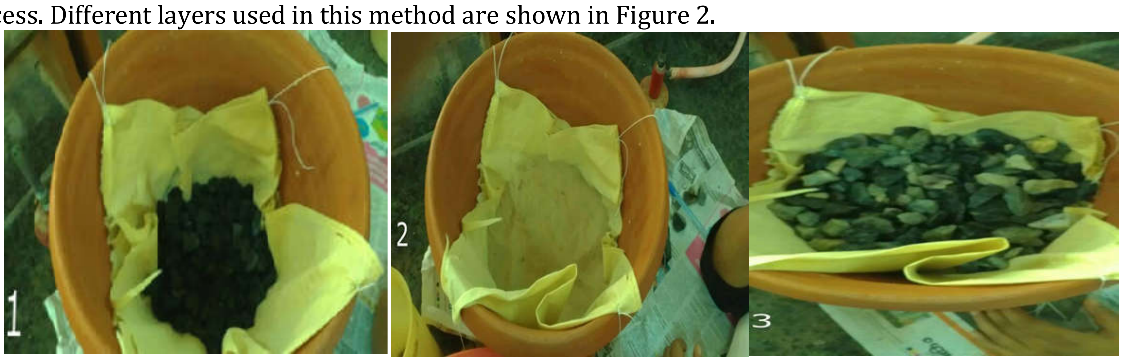

Fig 2: Structure of multilayer used in artificial wetland

Eight modifications were tried by keeping the layer 4, 3 and 2 fixed and changing the top most layers (layer 1) and are given in Table 1.

Table 1: Eight experiment set up with changing the first layer and keeping all other layer fixed

Experiment No	Top layer (first layer)
1	Pine apple leaf
2	Plantain fiber
3	Coconut husk fiber
4	Thin layer of all the three
5	Thick layer of all the three
6	Pineapple leaves and plantain fiber
7	Pineapple leaves and coconut husk fiber
8	Plantain fiber and coconut husk fiber

Testing of waste water and treated water

The polluted water was tested for physical, chemical and bacteriological characteristics. The polluted water passed through each layer and reached at the bottom portion of the pot. The holes in the pot are covered with a muslin cloth to hold back carbon and the purified water was collected through a tube. The clear water sample was collected and tested for its quality. The iron content of each sample was identified by testing the absorbance reading using the 'double beam spectrophotometer 2203' of Systronics.

RESULTS AND DISCUSSION

Role of different layers in the multilayer wastewater treatment system (from top to bottom)

Layer 1 (layer of agro-wastes)

Cellulose based fibrous membrane from agro-wastes (pineapple, plantain, coconut, etc.) helped in removal of toxic dyes and other contaminants from water. The top layer of agro-wastes acts as cellulose based Nano filters [1, 2].

Layer 2 (layer of gravel)

Layer of gravel was used to filter out larger sediment [19].

Layer 3 (layer of sand)

Layer of sand was used to filter out fine impurities. Organisms and particles collected in the top layer of the sand, gradually forming a bacterial zone to filter out bacteria, viruses and parasites [19].

Layer 4 (layer of activated charcoal)

Activated carbon was used to remove contaminants and impurities, utilizing chemical adsorption. Adsorption with active carbon is often used as tertiary purification for the removal of organic micro-pollutants and COD, and metals in organic complexes to a lesser extent, from waste water [19, 13, 14].

Role of agro-wastes on waste water treatment

In this method, the top layer was filled with agro-wastes (like pineapple leaves, coconut husk fiber, and plantain fiber). Each of them has different mechanism on treating waste water.

Pineapple leaves

Pineapple leaves yield a strong, white, silky fiber. The outer long leaves of pineapple are preferred for fiber. Pineapple leaf consists of cellulose, holocellulose, hemicelluloses and lignin along with some extraneous material called extractives such as gum and resin. Previous research indicates pineapple leaf fiber contained higher cellulose content than wood fiber. Pineapple leaf fibers also consist of lignin [9], an adhesive component that binds the cellulose and hemicellulose. Pineapple leaf has lowest lignin (10.5%) rather than banana stem (18.6%), oil palm (20.5%) and coconut (32.8%).In addition to that, it contains high holocellulose content (87.6%) than banana stem (65.2%), oil palm (83.5%) and coconut (56.3%).Thus, the properties depend on the content of chemical composition in the pineapple leaf fiber [3]. The cellulose based fibrous membrane from the pineapple leaf agro-waste helped in the removal of toxic textile dyes, and other contaminants from water.

Plantain fiber

Dietary fibers may have prebiotic effects mediated by promotion of beneficial bacteria. It is effective in blocking *E. coli* [6]. Banana stem juice acts as a natural coagulant for the treatment of wastewater [13, 16]. Three main parameters, namely, chemical oxygen demand (COD), suspended solids (SS), and turbidity of effluent were removed by the plantain fiber.

Coconut husk fiber

Coconut husk fiber does a bio filtration technique on the treatment of waste water. The system with the layer of coconut husk-based filtering media biologically treats the pollutants and acts as a barrier to retain solids. Coconut husk fiber can remove 90% of BOD and COD [11, 23].

Total Quality Monitoring of the polluted water sample

Table 2 shows the results of physical and chemical analysis of the water sample taken from the canal.

Table 2: Physical and chemical analysis report of the original waste water sample

Sl. No.	Characteristics	Units	Actual contents
1	Colour	Hazen / Pt. Co. Units	BLACK
2	Turbidity (NTU)	NTU	38.7
3	pH		6.40
4	Electrical conductivity	µs/cm	572
5	Temperature	°C	26.2
6	Acidity	mg/litre	36
7	Alkalinity	mg/litre	116
8	Sulphate (as SO_4)	mg/litre	60.6
9	Total Dissolved Solids (TDS)	mg/litre	288
10	Total hardness ($CaCO_3$)	mg/litre	146
11	Calcium (Ca)	mg/litre	40
12	Magnesium (Mg)	mg/litre	11.178
13	Chloride (as Cl)	mg/litre	194
14	Fluoride (as F)	mg/litre	0.205
15	Iron (as Fe)	mg/litre	1.428
16	Nitrate (as NO_3)	mg/litre	1.227
17	Residual chlorine (Rc)	mg/litre	NIL

The bacteriological analysis of the sample is given in Table 3.

Table 3: Bacteriological analysis

Sl. No.	Source	MPN of coliforms in 100 ml	MPN of *E.coli*
1	Pond water	1100+	1100+

Observations based on the above analysis were given below.

- The colour of the water sample as black which indicates the water was highly polluted.
- The turbidity measurement shows the sample water was highly turbid due to the presence of chemical and bacteriological contaminants.
- The pH value shows that the sample was slightly acidic.

- A large variation of iron content was seen in the water sample, which shows the site was rich in iron contamination and thereby rich in iron consuming bacteria.
- Bacteriological analysis of the water sample showed it has high *E.coli* contamination, which indicates that the site was an inlet of nearby drainage or toilet waste.

The quality improvement water after experiments

Iron removal efficiency

The iron content in the water samples after passing through the eight modified set up as in table 1 was given in Table 4.

Table 4: Iron content in water samples after filtration

Experiment No	Top layer (first layer)	Iron Concentration (mg/litre)
1	Pine apple leaf	0.28
2	Plantain fiber	0.24
3	Coconut husk fiber	0.26
4	Thin layer of all the three	0.24
5	Thick layer of all the three	0.22
6	Pineapple leaves and plantain fiber	0.18
7	Pineapple leaves and coconut husk fiber	0.20
8	Plantain fiber and coconut husk fiber	0.24

From the table 4, it was noted that in all cases the iron content in the water samples comes within the specification limit of less than 0.3 ppm (0.3 mg/litre). The maximum iron removing was observed in experiment No. 6 having pineapple and plantain fiber on the first layer of the filtration system. The iron removing capacity of single material in the top layer of the system were in the order, plantain fiber > coconut husk fiber > pine apple leaf. The efficiency of iron removal increases in combinations and maximum iron removal was noted in system having combination of pineapple leaves and plantain fiber in the first layer of filtration set up for water treatment process.

The other properties of the filtered water samples

The table 5 shows the quality of water sample obtained in the experiment No. 6 which is the best result given for iron removal values.

Table 5: Quality of output water in experiment set up No. 6

Sl. No.	Characteristics	Units	Actual contents
1	Colour	Hazen / Pt. Co. Units	4, (Clear)
2	Turbidity (NTU)	NTU	10
3	pH		6.40
4	Electrical conductivity	µs/cm	230
5	Temperature	°C	26.2
7	Alkalinity	mg/litre	100
8	Sulphate (as SO_4)	mg/litre	30
9	Total Dissolved Solids (TDS)	mg/litre	150
10	Total hardness ($CaCO_3$)	mg/litre	120
11	Calcium (Ca)	mg/litre	35
12	Magnesium (Mg)	mg/litre	11
13	Chloride (as Cl)	mg/litre	150
14	Fluoride (as F)	mg/litre	0.2
15	Iron (as Fe)	mg/litre	0.18
16	Nitrate (as NO_3)	mg/litre	1.2
17	Residual chlorine (Rc)	mg/litre	NIL

Parameters like as colour, turbidity, hardness etc lies in the desired limits shows the effectiveness of the treatment system. This was due to the better adsorptive nature of the agrowastes.

Bacteriological analysis of treated water samples

The bacteriological analysis of the treated samples did not show much improvement in the elimination of coliforms. This may be due to the bacterial contamination present along with the remaining adhesive particles present in the treatment system. This can be further improved by proper cleaning and drying of the plant materials before its application on water purification and by increasing the thickness of the treatment system. Chlorination can also be included in the system to eliminate bacteriological contaminations.

CONCLUSION

The absorptive capacity of a natural wetland is the mechanism used in the construction of artificial wetland for the purpose of treating wastewater. Constructed wetlands have the advantage over alternative treatment systems in that they require little or no energy to operate. In this study a new method for domestic waste water treatment through modified multi-layer artificial wetland was applied. The modification was done by replacing vegetation by layering the top portion with agro-wastes (such as pineapple leaves, plantain fibers, coconut husk fibers, etc.). This made the experiment cost effective for purification of waste water. The top layer of agro-wastes should be changed routinely within 5 -7 days. The above said agro-wastes are easily available in the agricultural sector of Kerala. The iron removing capacity of single material in the top layer of the system were in the order, plantain fiber > coconut husk fiber > pine apple leaf. The efficiency of iron removal increases in combinations and maximum iron removal was noted in system having combination of pineapple leaves and plantain fiber in the first layer of filtration set up for water treatment process. Water quality Parameters like as colour, turbidity, hardness etc lies in the desired limits shows the effectiveness of the treatment system. This was due to the better adsorptive nature of the agrowastes. Its efficiency increases when it is combined with pineapple leaves in the water treatment process. The waste water treatment process efficiency can be increased by using thick layer of pine apple leaf and plantain fiber.

REFERENCES

1. Alexis Wells Carpenter, *et.al*. (2015). "Cellulose Nanomaterial's in Water Treatment Technologies", *Environ. Sci. Technol*. 49(9), 5277–5287.
2. Ali,I. *et al.* (2012). "Low cost adsorbents for the removal of organic pollutants from wastewater", *Journal of Environmental Management*, 13, 170-183.
3. Asha Devi & Deepak Ganjewala (2011)."Antioxidant Activities of Methanolic Extracts of Sweet-Flag (*Acorus calamus*) Leaves and Rhizomes", *International Journal of Drug Development and Research*, 17(1), 1-11.
4. Asim M. et al; (2015). "A Review on Pineapple Leaves Fiber and Its Composites", *International Journal of Polymer Science*, 1-16.
5. Brix, Hans, (1994). Use of constructed wetlands in water pollution control: Historical development, present status, and future perspectives, *Wat.Sci.Tech*, 30(8), 209 - 223.
6. Carol L. Roberts, *et. al*; (2013). "Soluble plantain fiber blocks adhesion and M-cell translocation of intestinal pathogens", *The Journal of Nutritional Biochemistry*, 24(1), 97–103.
7. Catling, P.M. & Mitrow, G.l, (2011). "Major invasive alien plants of natural habitats in Canada. 1. European Common Reed (often just called Phragmites), *Phragmites australis* (Cav.) Trin. ExSteud. subsp. australis", *CBA Bulletin,* 44(2), 52–61.
8. Coleman, J. *et al*., (2001). Treatment of Domestic Wastewater by Three Plant Species in Constructed Wetlands, *Water, Air, & Soil Pollution*, 128(3), 283–295.
9. Daud, Z. et al. (2015). "Analysis by Pineapple Leaf in Chemical Pulping Process", *Applied Mechanics and Materials*, 773, 1215-1219.
10. ElZein, Z. *et al*., (2016). Sustainable Communities; Constructed Wetlands; Urban Water; Gray water; Sustainability, Water Resources; Water Reuse, *Procedia Environmental Sciences*, , 34, 605–617.
11. Etim U. J. et.al. (2016). "Coconut coir dust as a low cost adsorbent for the removal of cationic dye from aqueous solution", *Journal of Saudi Chemical Society*, 20(1), S67-S76.
12. Grace, J. B. & Wetzel, R. G. (1981). Habitat partitioning and competitive displacement in cattails (Typha): experimental field studies, *The American Naturalist*, 118, 463–74.
13. Habsah Alwi *et al*. (2013). "A preliminary study of banana stem juice as a plant-based coagulant for treatment of splent coolant wastewater", Journal *of chemistry*, 1-7.
14. Haider. M. Zwain *et al*. (2014). "Waste Material Adsorbents for Zinc Removal from Wastewater: A Comprehensive Review", *International Journal of Chemical Engineering*, 1-13.
15. Idris J. *et.al*. (2014). "A Preliminary Study of Biodegradable Waste as Sorbent Material for Oil-Spill Cleanup", *The Scientific World Journal*, 1-8.
16. Kaoru Abe, *et.al.* (1997). "Introduction of fiber plants to plant bed filter systems for wastewater treatment in relation to resource cycling", *Soil science and plant nutrition*, 43(1), 35-43.
17. Keddy *et al*., (2009). Ecosystem function, ecosystem service, global priority, largest wetlands, wetland conservation, *BioScience*, 59(1), 39–51.
18. Leng, R A. *et al.* (1995) "Duckweed - a potential high-protein feed resource for domestic animals and fish", *Livestock Research For Rural Development*, 7(1), 1-11.
19. Lu S. et al., (2015). "Study on method of domestic wastewater treatment through new-type multi-layer artificial wetland", *International Journal of Hydrogen Energy*, 40(34), 11207–11214.
20. Malik, D.S. *et al.* (2016). Removal of heavy metals from emerging cellulosic low-cost adsorbents: a review||, *Applied Water Science,* 1–24.
21. Mohan D. *et.al,* (2008). "Wastewater treatment using low cost activated carbons derived from agricultural byproducts—a case study", J*ournal of hazardous materials*, 152(3) 1045-1053.

22. Moreno-Castilla C, (2004). "Adsorption of organic molecules from aqueous solutions on carbon materials", *Carbon*, 42, 83–94.
23. Richard J. Frankel, (1979). "Operation of the Coconut Fiber/Burnt Rice Husks Filter for Supplying Drinking Water to Rural Communities in Southeast Asia", *AJPH*, 69(1), 75-76.
24. Salt DE et al. (1998). "Phytoremediation": Annual Review of Plant Physiology and Plant Molecular Biology, *Annual Reviews,* 49(760), 643–668.
25. Saltonstall, K, *et al.* (2004). "Recognition of *Phragmites australis* subsp. Americanus (Poacaeae: Arundinoideae) in North America. Evidence from morphological and genetic analyses", *SIDA* 21(2), 683–692.
26. Selbo *et al*. (2004). "The potential for hybridization between *Typha agustifolia* and *Typha latifolia* in a constructed wetland" *Aquatic Botany*, 78(4), 361–369.
27. Scott D. A. & Jones T. A. (1995). Classification and inventory of wetlands: A global overview, *Plant Ecology*, 118 (1), 3-16.
28. Wagner, G.M. (1997). "Azolla: a review of its biology and utilization", *The Botanical Review,* 63(1), 1–26.

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