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Removal of Heavy Metals from Cooum River by Using Constructed Wetland

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Abstract: The concentration of pollutant such as Heavy metals (Fe, Cu, Cd),Turbidity ,BOD, COD, Phosphate, TSS, TDS, Total Coliforms and Feacal coliforms. Constructed wetland system was operated for a period of 4.5 months with loading rate of 20L/day/m2. The achieved removal efficiencies for Cooum river water for Heavy metals (Fe, Cu, Cd), Turbidity, BOD, COD, Phosphate, TSS, TDS, Total Coliforms and Feacal coliforms were (100%, 100%, -), 96%, 58%, 53%, 100%, 42%, 24%, 99%, and 99% respectively. The achieved removal efficiencies for cooum river water spiked with heavy metal concentrations of 1mg/L for Heavy metals (Fe, Cu, Cd), Turbidity ,BOD, COD, Phosphate, TSS, TDS, Total Coliforms and Feacal coliform were (100%, 96%, 100%), 90%, 74% , 68%, 100%, 32%, 32%, 100% and 100% respectively. The achieved removal efficiencies for Cooum river water spiked with Heavy metal concentration of 5mg/L for Heavy metals (Fe, Cu, Cd), Turbidity, BOD, COD, Phosphate, TSS, TDS, Total Coliforms and Feacal coliform were (46%, 37%, 41%), 96%, 79%, 71%, 100%, 72% ,40%, 99% and 99% respectively. The optimum concentration of 2.5mg/L for 20 L/day/m2 with VFCW is proved better effective for the Heavy metal removal.

Keywords – Constructed wetland system, temperature, BOD, COD, Phosphate.

I. INTRODUCTION

1.1 GENERAL

Water is the most important element for the survival of human life and industrialization. Due to rapid urbanization the water quality gets degraded and it is made unfit for drinking and domestic purposes. The major sources of pollution are chemical fertilizers and pesticides running into the untreated sewage, dumping of solid waste, discharge of the industrial effluents into a nearby river stream that is running close to the cities. In this study there was a main focus on the improvement of the Cooum river water quality. Cooum river the urban river of Chennai which starts from Coovum 70Kms from the city in Thiruvallur district adjoining to the Chennai district. The length of the river is 65Kms and flows into three corporation zones of Nungambakkam, Triplicane and Kilpauk which covers about 18 Kms. In the city limit it originates from Paruthipattu and ends at the Napier Bridge where the river mixes with the Bay of Bengal. The Cooum river was once the source of the fresh water and today it is a drainage course collecting surpluses of 75 small tanks of minor basin (Sheriff & Hussain, 2012). The physico-chemical analysis of the river water quality along the city limits that is the point where the river is entering and the point where the river is discharging (Parutipattu to Napier Bridge) are carried out and based on the analysis, wetland treatment was adopted

1.2 NEED FOR THE STUDY.

The Cooum river water was once the source of fresh water and it was used for variety of purposes and now it is the most polluted river within the city limits that is 18 kms of the river was found to be polluted. Due to increase in population around the city there is a need to establish an onsite treatment system across the river to improve the quality. So this project deals with the water quality analysis and adoption of the simplest cost effective treatment method for the field implementation to restore the river water quality concentrations. Continued greenhouse gas emissions at or above current rates would cause further warming.

1.3 OBJECTIVES

The main objectives of this project are
•Water Quality Analysis of the river
•To use lab scale model of constructed wetland system for treating the cooum river water with heavy metals.

2. LITERATURE

2.1 GENERAL

Heavy metal pollution in the Cooum river water is mainly due to industrialisation, urbanisation and discharge of untreated sewage to rivers. The heavy metals present in the river causes contamination in the ground water. The wetland method is considered as the cost

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Vol 5, Issue 4, April 2018

effective and effective treatment for the removal of the pollutants and increasing the DO of the river water.

2.2 STUDIES ON RIVER WATER QUALITY

In a study, water samples were collected from five different stations: four from Cooum river at Nagalkeni, Chembarambakkam, Chetpet and Chepauk; one from Adyar river at Sidapet. The analysis revealed the range of pH to be from 6.2 to 7.6, whereas TDS ranged from 1320-5900mg/L which is higher than drinking water standard. The ground water analysis near sampling sites showed the presence of Gram positive and Gram negative bacteria (Abraham, 2012). The study made by Sheriff & Hussain (2012) the bore water samples are collected from the banks of cooum river. The COD value was found to be within the range of 0.2-92 ppm whereas the standard value is 10 ppm, there is a contamination of organic pollution. Similarly in the case of BOD the value ranges from 0.4-12.5 ppm. Whereas in the case of TDS the samples were found be double or triple times more than the standard that is 1093-1484 ppm.

3. MATERIALS AND METHODS

3.1 GENERAL

Water samples were collected from 15 points and analysed. Wetland with Arundo donax was studied with water samples collected from Arumbakkam which showed higher heavy metal contamination while comparing all stretch points in cooum river. Even though heavy metal contamination was found it was not very high which could be used to find the efficiency of the plant. So the further study river water was spiked with Iron, Copper and Cadmium at various concentrations.

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3.2 OVERVIEW OF METHODOLOGY

Treatment of Cooum River water using Constructed Wetland system involves construction of the wetland, monitoring and determination of various parameters (BOD, COD, TDS, TSS, pH, PO43-, Heavy metals, Total Coliforms, Fecal Coliforms and Turbidity).

The overall methodology of the present study is shown in the flow chart Figure 3.1

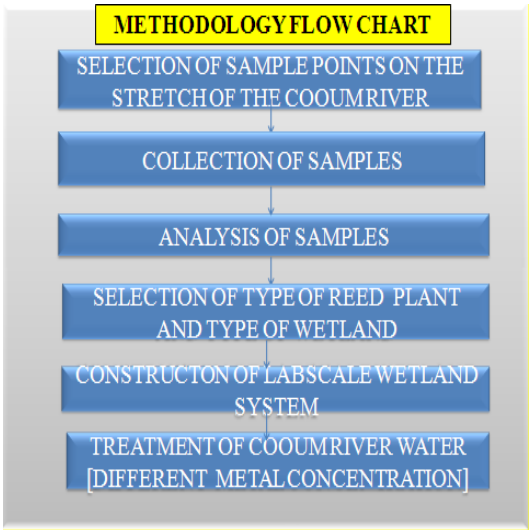

Fig 3.1 Overview of Methodological Framework

3.3. MATERIALS

3.3.1 Identification of Sampling Locations

15 Stretch Points

•Paruthipattu
•Thiruverkadu
•Perumalagaram
•Vanagaram
•Adayalapattu
•Nolambur
•Nerkundram
•Thirumangalam
•Near TNPCB Office (Arumbakkam)
•Near Jain Marriage Hall (Arumbakkam)
•Aminjikarai
•Chetpet Bridge
•Harris Bridge
• Near central jail
•River mouth- Napier Bridge

The Sampling location was fixed based on the Analysis. The collected sample was used for treatment. From these 15 points, the region near TNPCB office near Arumbakkam region was found to have high concentration of heavy metals. So this sample was taken for analysis and subjected to treatment.

3.3.3 Collection of Water Sample

The Cooum River water samples were collected by using telescopic sampler and sampling bucket from the surface of the water and then stored in a dry polythene bottles and the bottles were given proper labelling.

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Vol 5, Issue 4, April 2018

3.3.4 Chemicals and Reagents

The chemicals needed for testing the water quality analysis were Sodium thiosulphate, Sulphuric acid, Nitric acid, starch, Magnesium Sulphate, Potassium Iodide, Calcium Chloride, Ferrous Chloride, Phosphate buffer, Silver Nitrate, Potassium dichromate, Hydrochloric acid, BGLP media, Silver Chloride, Mc-konkey broth, Copper sulphate, Ferrous sulphate, Cadmium nitrate tetrahydrate, Nitric Acid and Stannous chloride.

3.3.5 Parameters and Methods

The parameters that were taken for the river water analysis was

•pH - Electrometric Method
•Turbidity - Nephlometer
•BOD - Tritrimetric method
•COD - Open reflux method
•TDS - Conductivity
•PO43- - Stannous Chloride Method
•HeavyMetals - by Atomic Absorption Spectrophotometer
•Toatal Coliforms - MPN method
•Fecal Coliforms - MPN method

3.3.6 Equipments

The equipments required to carry out the testing are as follows:

•pH meter
•BOD incubator
•COD digester
•Atomic Absorption Spectrophotometer
•Conductivity meter
•UV-Spectrophotometer

3.3.7 Design of Constructed Wetland

STORAGE TANK

Cylindrical tank was chosen for the storage tank.

Diameter = 25cm
Height = 40cm
Volume = 19634cm3
Tank Capacity = 20L

The sample was loaded continuously into the constructed wetland.

CONSTRUCTED WETLAND

Height = 35cm
Surface Area = L x B
= 0.48 x 0.48
= 0.230 cm2
Length/Breadth = 1

1:1 ratio is adopted for the design

Volume = 0.230 x 0.35
= 0.080 m3.

4. RESULTS AND DISCUSSION.

4.1 CHARACTERISTICS OF COOUM RIVER WATER

Heavy metal concentration along the Cooum river at 15 sampling stations points were analysed and the results are shown in the Table 4.1. From the results the station which has very high concentration of metals was taken for the wetland treatment.

Table 4.1 Heavy Metal Analysis along the Stretch Points

Parameters	Arsenic (mg/L)	Cadmium (mg/L)	Copper (mg/L)	Lead (mg/L)	Chromium (mg/L)	Nickel (mg/L)	Zinc (mg/L)	Mercury (mg/L)	Iron (mg/L)
Paruthipattu	BDL	0.06	0.65	0.13	0.11	0.08	1.06	BDL	1.79
Thiruverkadu	BDL	0.03	0.18	0.14	0.07	0.09	0.71	BDL	1.66
Perumal agaram	0.02	0.02	0.04	BDL	BDL	BDL	0.18	BDL	0.63
Vanagaram	BDL	0.02	0.06	BDL	BDL	BDL	0.16	BDL	1.34
Adayalapattu	BDL	BDL	0.05	BDL	BDL	BDL	0.21	BDL	1.43
Nolambur	BDL	BDL	0.04	0.06	BDL	BDL	022	BDL	1.21
Nerkundram	BDL	0.02	BDL	BDL	BDL	BDL	0.28	BDL	1.47
Thirumangalam	BDL	0.03	0.22	BDL	BDL	BDL	0.33	BDL	2.11
TNPCB Office	**BDL**	**0.11**	**0.38**	**BDL**	**BDL**	**BDL**	**0.72**	**BDL**	**7.39**
Arumbakam	BDL	0.03	0.07	BDL	BDL	BDL	0.18	BDL	1.67
Aminjikarai	BDL	BDL	0.05	BDL	BDL	BDL	0.18	BDL	2.57
Chetpet Bridge	BDL	BDL	0.05	BDL	BDL	BDL	0.12	BDL	1.90
Harris Bridge	BDL	0.01	BDL	BDL	BDL	BDL	0.04	BDL	0.47
Central Jail Bridge	BDL	0.01	0.07	BDL	BDL	BDL	0.17	BDL	0.62
Napier Bridge	0.09	0.01	0.13	BDL	BDL	BDL	0.14	BDL	0.95
	DL (0.005)	DL (0.01)	DL (0.03)	DL (0.05)	DL (0.05)	DL (0.05)	DL (0.01)	DL (0.001)	DL (0.05)

4.2 CHARACTERISTICS OF FILTER MEDIA

The basic property of the filter media such as Depth, Effective size, Porosity, Voids ratio, Specific gravity, Moisture Content, Density, Unit Weight, Hydraulic conductivity were studied. Based on the study 1mm sand was used as filter media which had a

4.3 PERFORMANCE OF THE WETLAND SYSTEM

The wetland was used for the treatment of the Cooum river water sample collected from the Arumbakkam near TNPCB office. During the analysis, it was found that the Cooum river contain minimum amount of heavy metals hence, the wetland treatment was carried out initially with the Cooum river sample then further treatment was made by spiking with heavy metals to the Cooum river water with sampling intervals of 5, 10, 15,

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Vol 5, Issue 4, April 2018

20, 25 and 30 days respectively, at a loading rate of 20L/m2/day. Samples were collected and characterised for each pollutant for both the influent and effluents in the CWS.

4.4 Cooum River Water

Initially, inlet concentration of iron from the Cooum river water was 0.12mg/L. During 5 days of treatment the concentration of Iron was 0.07mg/L with 42% removal efficiency, and complete (100%) removal of iron takes place on 10th day. Copper concentration in the Cooum river was 0.06mg/L which is slightly higher than the drinking water standard that is 0.03mg/L, in the beginning of the study the removal efficiency was not high, but on 10th day complete (100%) removal of copper takes place.In case of cadmium at the time of sampling the concentration was found to be within the detection limit, hence there was absence of cadmium concentration along the Cooum river water. The removal of heavy metal in CWS was due to binding to sediments and soils, precipitation as insoluble salts, and uptake by plants and bacteria. Kadlec & Knight(1996). The figure 4.1 and 4.2 shows the concentration of heavy metals and their removal efficiency.

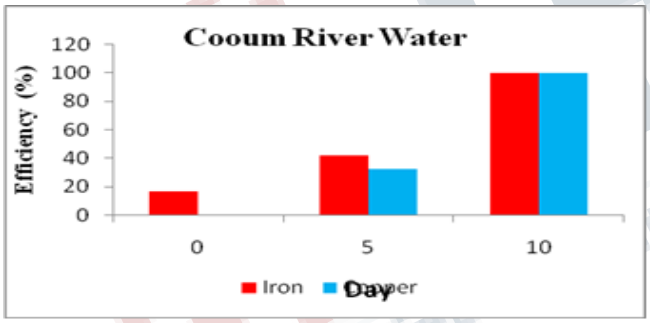
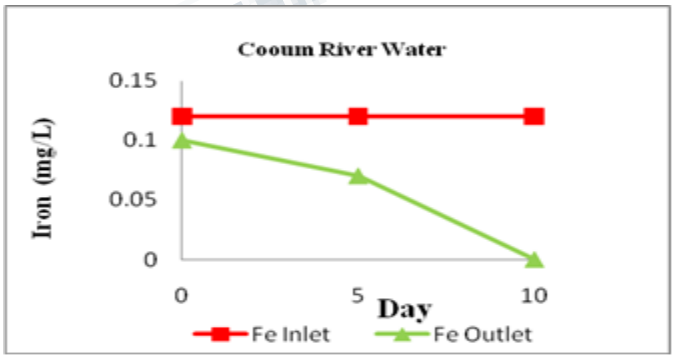


Fig.4.2 Efficiency of Removal of Heavy Metals



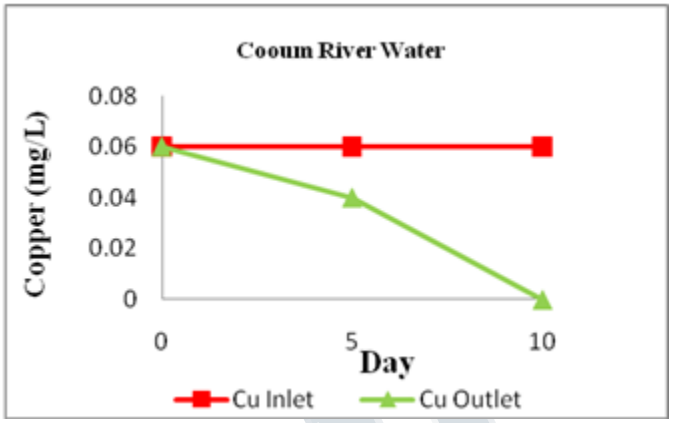


Fig. 4.1 Concentration of Heavy metals

4.4.2 Cooum River Water Spiked with Heavy Metals (1mg/L)

The Iron concentration was increased in Cooum river water by spiking with Iron Sulphate at 1mg/L. The inlet concentration was 1.2 mg/L. On the 5th day of treatment, iron concentration reduced to 0.71 mg/L with 41% removal efficiency, on 10th day of treatment the iron.

5. SUMMARY AND CONCLUSIONS.

5.1 SUMMARY

In this research, the performance of the constructed wetland were monitored for the various heavy metal concentrations and the summary of the findings are reported as follows.

•The sampling locations are fixed along the coum river water and from the 15 points the sampling station which is rich in heavy metal concentration were taken for the wetland treatment.

•The filter media that is to be adopted for the wetland was studied for the various characteristics and the one with the better permeability and porosity was adopted that is the 1mm sieve size sand and 10 to 15mm blue metal was adopted as the filter media for the study.

•The coum river water from Arumbakkem TNPCB office was taken for the study in the vertival flow constructed wetland with Arundo donax, at the loading rate of 20L/day/m2.

• Heavy metals like Iron, Copper and cadmium were studied, since there was minimum concentration was found in the river the heavy metal concentration was further increased in the river water by spiking it with the heavy metals of varying concentrations of 1mg/L, 2.5mg/L and 5mg/L respectively.

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International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 4, April 2018

•There was a complete removal of heavy metal takes place for cooum river water, 1mg/L, 2.5mg/L whereas in case of 5mg/L the heavy metal removal efficiency was reduced. The optimum heavy metal was found to 2.5mg/L for the plant growth and treatment.
•The heavy metals were accumulated in the plants root, leaf and stem this proves that the plant intakes heavy metal the maximum intake was found for iron, copper and then cadmium.
•There was a complete removal of phosphate, Total coliforms, and Feacal coliforms. In case of turbidity on completion of treatment process, it reached the drinking water standard, and pH was found to be within the specified limits.
•In case of organics and solids the maximum removal was in the range of 80-85% and 50-70% was achieved.

5.2 CONCLUSIONS

Each technology has its unique opportunities, benefits and challenges. From the present study it is evident that, treatment of Cooum river water by using simple Constructed wetland system will be better solution. Where the sunlight is used as the energy source and the plant is used for the treatment which can be used as the improvement of aesthetic as well as treatment process for the contaminated Cooum river water with minimum labour and maintenance cost. The toxic heavy metals can also be removed by this method. The optimum heavy metal concentration at which the plant was able to uptake was found to be 2.5mg/L. Further the river water can be improved by using various other treatments, and this is one among them.

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