PHYTOTECHNOLOGY FOR TREATEMENT OF SULLAGE WATER USING OUTDOOR PLANTS

Abhishek Rudragouda Patil[1], **Rekha H.B.**[2],

[1] PG Student, [2] Associate Professor, Department of Civil Engineering, UVCE, Bangalore University, Bengaluru, Karnataka, India.

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Abstract: The sullage water contains a variety of impurities, it must be treated. The sullage water comes from the canteen; restaurants and home kitchens are also major polluters. Surface water pollution is a major issue in India, with chemicals, organic and inorganic, biological and toxic substances contaminating 72 percent of surface and ground water. The aim of this study is to see how effective Phytotechnology is at treating sullage water. It is a more efficient and long-term alternative to traditional wastewater treatment methods. In this study we are analyse the performance of Phytotechnology for removal of pollutants such as Chemical oxygen demand (COD), Biological oxygen demand (BOD), Total dissolved solid (TDS) etc. of kitchen wastewater at 24, 48, 72, 96 hours of Hydraulic retention time from the kitchen wastewater as plants play a great role in the treatment of pollutants. This study will give the eco-friendly way and less cost of Maintenance and operation. It reveals that proper treatment of kitchen wastewater can lead to higher profitability for community and save environmental pollution.

Key words: Phytoremediation, outdoor plants, sullage, Biochemical Oxygen Demand, Chemical Oxygen Demand and dissolved solids.

1. INTRODUCTION

Phytotechnology is a growing field that uses plants to solve scientific and technological issues. The majority of current research in this area has focused on the contaminate removal method known as phytoremediation. Chaney (1983) was the first to invent this technology, which was later refined through research into plant species' ability to eliminate contaminants from environmental components.

Phytotechnology is type of passive wastewater treatment that removes pollutants from the environment using plant-based systems and microbiological methods. Phytotechnology is based on the physiochemical properties of the plants and associated microorganisms, such as photosynthesis metabolism and mineral nutrition. The plants used in experiment are areca palm plant, rice plant, grass, rose moss, and annual vinca plant.

A. Neharika Chandekar et al (2015): explored the use of phytoremediation to treat waste water. They used plants to remove pollutants from waste water because they are cost-effective and need relatively little operation and maintenance. The phytoremediation system has a high rate of pollutant elimination with a varying of HRT. They have looked at marine plants and how effective they are at removing pollutants in this article. Plants produce strong results in cooler environments, according to their research. The sort of cultivated beds has an effect on the elimination of pollutants. Since it is easy to grow in any local climatic condition, the canna plant is a good choice for plantation in the growth of wetlands.

B. Amin Mojiri et al (2012): study that Polluted soils and waterways are a significant environmental and human health concern, which can be partially solved by new phytoremediation technologies. These findings suggested that Typha domingensis may be useful in reducing heavy metals in urban wastewater. These findings have revealed that Typha domingensis was more effective at removing heavy metals from wastewater after 48 hours than it was after 24 hours.

C. Buddharatna J. Godboley et al (2015): investigated phytoremediation technologies for the treatment of kitchen waste water in this article. After examining parameters such as TSS, TDS, BOD, and COD during the pre- and post-treatment processes, it was determined that phytoremediation is a long-term solution for treating kitchen wastewater. The phytoremediation method was carried out in this analysis in 1 day HRT. And they discovered that when the hydraulic retention time (HRT) approaches one day, the removal efficiencies are 86.74 percent reduction in BOD, 92.88 percent reduction in COD, 74.55 percent reduction in TSS, and 71.44 percent reduction in TDS in those beds.

Objectives of the study include

- Lab scale set up of phytoremediation done using outdoor plants.
- Determination of initial and final characteristics of waste water by analysing pH, BOD, COD, TDS and turbidity etc.

ISSN: 2582-3930

- Determination of efficiency of sullage water treatment by using are areca palm plant, rice plant, grass, rose moss, and annual vinca plant. at varied treatment hours of 24, 48, 72, 96 hours respectively.

- Determination of percentage of removal of contaminants using different plants at varied treatment hours of 24, 48, 72, 96 hours respectively.

- To check with disposal standard as per IS 3307:1965 for their discharge on land irrigation.

MATERIALS AND METHODOLOGY

2. Methodology

The experimental set-up was used to treat the sullage water. The schematic diagram of experimental setup is shown in figure 2.1. The treatment process consists of the primary treatment which was used to remove the suspended solids and organic matter from the kitchen wastewater which may become the barrier while biological treatment of kitchen wastewater (Neharika S, 2015). The experiment model of phytoremediation system has set up in the environmental engineering lab, Department of Civil Engineering, UVCE, Bangalore University, Bangalore-560056. Sullage water sample was collected in plastic cans from kitchen at Engineering hostel mess, Bangalore University, J B campus, Bangalore -560056. Waste water passed through the bed through plastic pipes by gravity flow as shown in fig 2.2 (a) (b). The phytoremediation bed is installed with suitable inlet and outlet drainage pipe. The bed is regular rectangular size. Gravels of size 3mm, 10mm, 20mm are used in this experiment as filter media. Suspended solids are removed by filtration through filter bed. Outlet sample was collected in beaker at regular intervals of 24, 48, 72, 96hours (HRT) respectively. In this experiment plants play an important role in clean up processes. In this experiment setup flow rate was kept as 40ml per minute. The pH was ranging between 6 to 8.

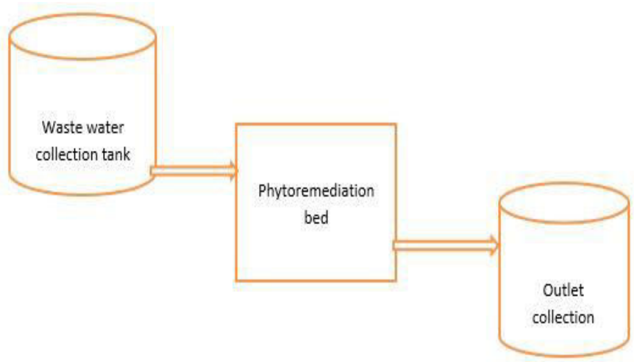

Figure 2.1.Phytoremediation Schematic Flow Diagram

(a)

(b)

Figure 2.2: Phytoremediation Experiment Setup

2.1 Methods of Analysis

Various methods were used in the analysis of the initial and final parameters of the sample. The parameters that were analysed using the different analytical methods are listed in table1. The analysis was done as per standard methods for water and wastewater analysis.

Table 2.1: Methods used in the Analysis of parameters

SL.No.	Parameters	Methods Used
1.	pH	pH meter
2.	Conductivity	Conductivity meter
3.	TDS	Gravimetric method
4.	BOD_5	Winkler Method
5.	COD	Closed reflux method
6.	Turbidity	Nephelometer / digital turbidity meter
7.	Temperature	Celsius thermometer

2.2 Methodology flow chart

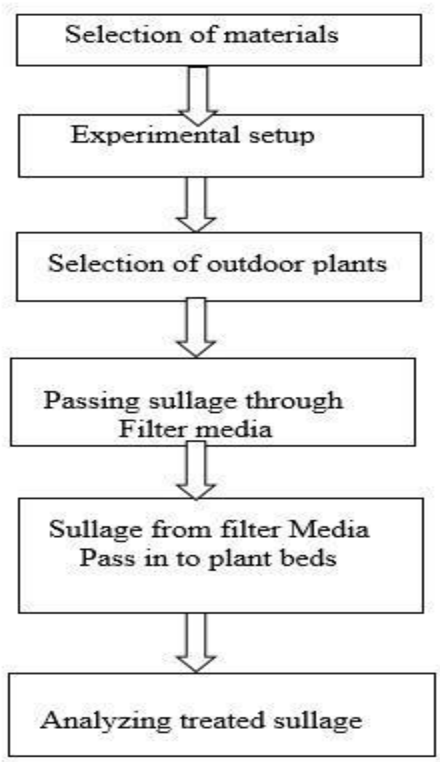

Fig 2.3: Experimental Process Flow chart

3. Design of bio filter

Rate of filtration (ROF) =1021.73 ml/min/m^2

Q = 40 ml/min (based on plant requirement)

Total area of filter required = $\frac{Q\ design}{ROF}$

$= \frac{40}{102173.}$

= 0.03914 m^2

Diameter of filter = d = $\sqrt{\frac{A*4}{\pi}}$

$= \sqrt{\frac{0.03914*4}{\pi}}$

= 0.225 m

Then, d provided = 25 cm.

Depth of the filter = 1.5 D = 1.5 x 25 = 37.5 cm

D provided = 40 cm

(reff: dhanuradha et al, 2018)

4. Design of bed

Design flow Q = $0.18\ m^3/_{day}$

(Based on requirement of water to all plants)

Hydraulic conductivity = ks =259 m^3/ day/m^2

Hydraulic gradient = S = 0.01

Cross sectional area based on design inflow = $\frac{Q}{ks * S}$

$= \frac{0.18}{259 * 0.01}$

= 0.069 m^2

Assume depth of bed = 0.2 m or 20 cm

Width of bed = $\frac{Area}{depth}$

$= \frac{0.069}{0.2}$

=0.345 m or 35 cm

Aspect ratio (L: w) =1.5:1

Length of the bed =1.5*0.35

= 0.517m or 52 cm

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT (IJSREM)
VOLUME: 05 ISSUE: 07 | JULY - 2021 ISSN: 2582-3930

5. RESULTS AND DISCUSSIONS

5.1 Results

This chapter reports the results obtained during the phytoremediation technique and their interpretations have been discussed in detail. In table 5.1 shows the results of sullage waste water characteristics

Table 5.1 Shown the Results of sullage Waste Water Characteristics.

SL.No	Parameters	Results
1	pH	7.50
2.	Conductivity	338 иs/cm
3.	TDS	969 ppm
4.	BOD_5	237 mg/L
5.	COD	640 mg/L
6	Turbidity	60 NTU
7	Temperature	18 C

Phytotechnology for treatment of different outdoor plants

The analysis was carried out to check the treatment efficiency of different plants like areca palm plant, rice plant, grass, rose moss plant and annual vinca plant. The results are shown in the following sections.

5.1.1 Areca palm plant

Table 5.2. Results Analysed for Removal of Contaminants from Sullage Water.

SL NO	Parameters	Sullage	24 hours	48 hour	72 hour	96 hour
1	pH	7.5	7.5	7.5	7.3	7.1
2	Conductivity in иs/cm	338	331	349	261	231
3	TDS in ppm	969	265	165	130	121
4	BOD_5 in mg/L	237	88.5	49.5	33	21
5	COD in mg/L	640	240	128	96	96
6	Turbidity in NTU	60	23	13	11	8
7	Temperature in C	18	18.1	18.2	18.4	18

From table 5.2 and fig 5.1-5.6 it's observed that there was marginal variation in the parameters like pH, TDS, BOD and COD .The analysis of sullage water samples after 24 hours to 96 hours of HRT, observed that the pH of the sullage water samples was varying to 7.1 to 7.5. The TDS content of the sample was reduced 969 ppm to 121 ppm. The variation in BOD is 237 mg/L to 21 mg/L. The COD of sample ranged between 640 mg/L to 96 mg/L. And the variation in TDS observed was 60 NTU to 8 NTU for 24 hours to 96 hours of treatment respectively. A huge decrease in waste content was seen in sullage water after four days of treatment with the areca palm plant.

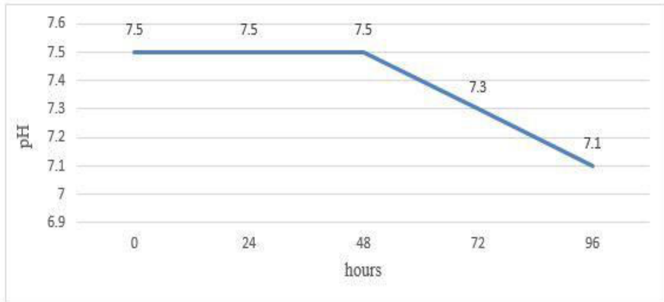

Fig 5.1 Variation in pH of Waste water

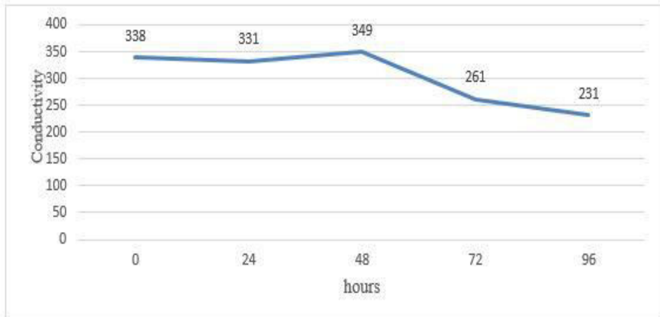

Fig 5.2 Variation in Electrical Conductivity of Waste Water

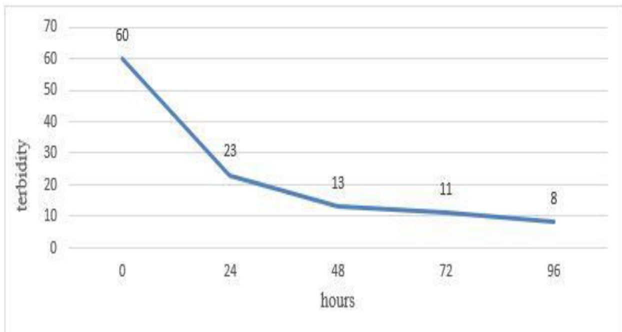

Fig 5.3 Variation in turbidity of Waste water

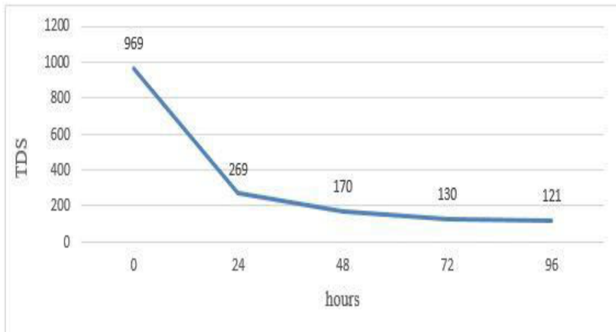

Fig 5.4 Variation in TDS of Waste water

ISSN: 2582-3930

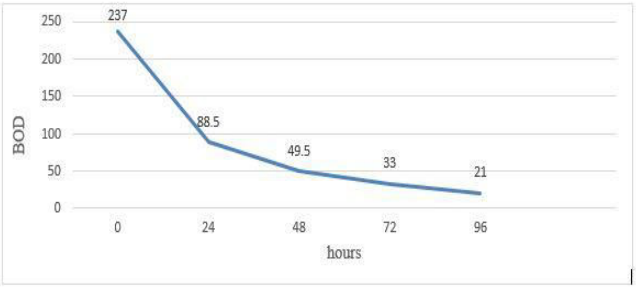

Fig 5.5 Variation in BOD of Waste water

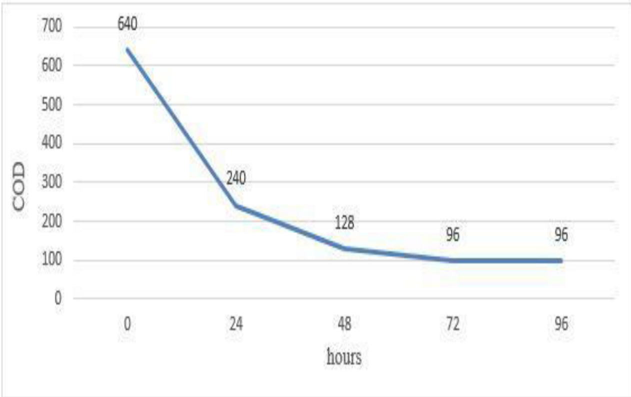

Fig 5.6 Variation in COD of Waste water

5.1.2 Rice plant

Table 5.3 Results Analysed for Removal of Contaminants from Sullage Water

SL NO	Parameters	Raw water	24 hours	48 hour	72 hour	96 hour
1	pH	7.5	7.5	7.3	7.3	7.1
2	Conductivity in µs/cm	338	331	349	261	231
3	TDS in ppm	969	285	130	114	109
4	BOD_5 in mg/L	237	126	64.5	42	41
5	COD in mg/L	640	224	160	128	102
6	Turbidity in NTU	60	28	12	9	5
7	Temperature in C	18	18.1	18	18	18

From table 5.3 and fig 5.7-5.12 it's observed that there was marginal variation in the parameters like pH, TDS, BOD and COD .The analysis of sullage water samples after 24 hours to 96 hours of HRT, observed that the pH of the sullage water samples was varying to 7.1 to 7.5. The TDS content of the sample was reduced 969 ppm to 109 ppm. The variation in BOD is 237 mg/L to 41 mg/L. The COD of sample ranged between 640 mg/L to 102 mg/L. The variation in TDS observed was 60 NTU to 5 NTU for 24 hours to 96 hours of treatment respectively. A huge decrease in waste content was seen in sullage water after 96 hours of treatment with the rice plant.

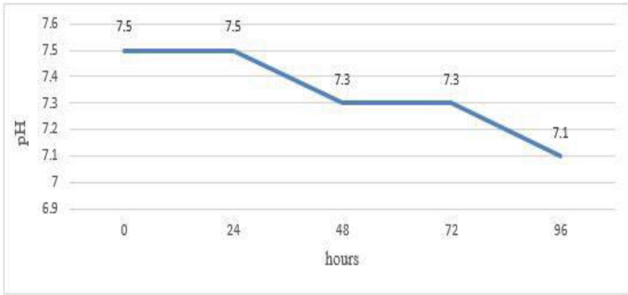

Fig 5.7 Variation in pH of Waste water

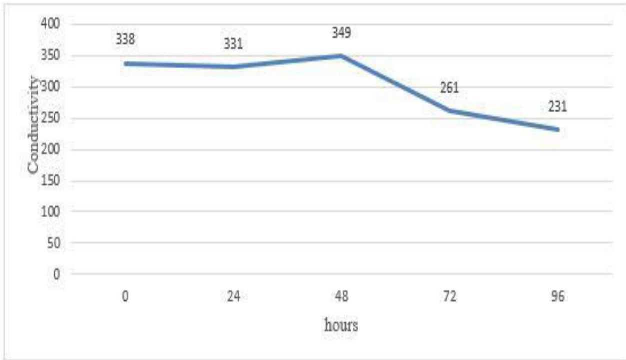

Fig 5.8 Variation in Electrical Conductivity of Waste Water

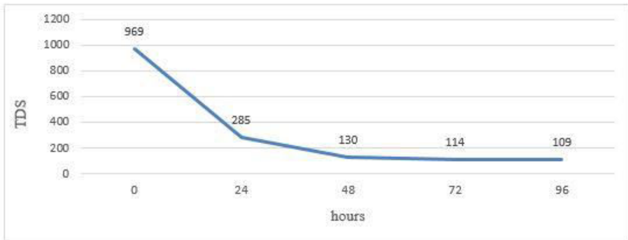

Fig 5.10 Variation in TDS of Waste water

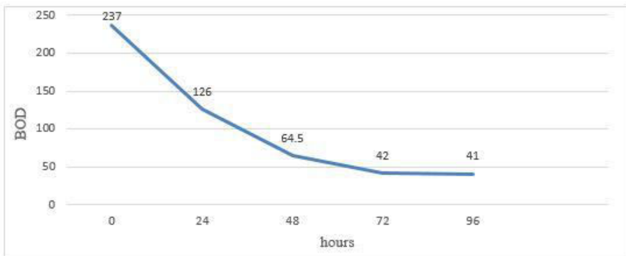

Fig 5.11 Variation in BOD of Waste water

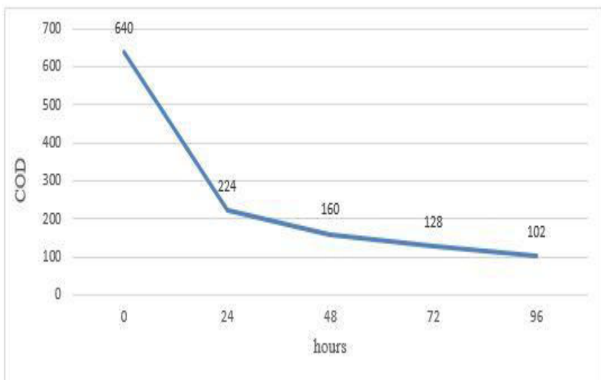

Fig 5.12 Variation in COD of Waste water

5.1.3 Grass

Table 5.4 Results Analysed for Removal of Contaminants from Sullage Water

SL NO	Parameters	Raw water	24 hours	48 hour	72 hour	96 hour
1	pH	7.5	7.5	7.3	7.3	7.1
2	Conductivity in иs/cm	338	293	268	231	222
3	TDS in ppm	969	243	144	130	121
4	BOD_5 in mg/L	237	144	46.5	36	33
5	COD in mg/L	640	292	112	86	85
6	Turbidity in NTU	60	29.4	13.2	11	6
7	Temperature in C	18	18	18	18	18

From table 5.4 and fig 5.13-5.18 it's observed that there was marginal variation in the parameters like pH, TDS, BOD and COD .The analysis of sullage water samples after 24 hours to 96 hours of HRT observed that the pH of the sullage water samples was varying to 7.1 to 7.5. The TDS content of the sample was reduced 969 ppm to 121 ppm. The variation in BOD is 237 mg/L to 33 mg/L. The COD of sample ranged between 640 mg/L to 85 mg/L. The variation in TDS observed was 60 NTU to 6 NTU for 24 hours to 96 hours of treatment respectively. A huge decrease in waste content was seen in sullage water after 96 hours of treatment with the grass plant.

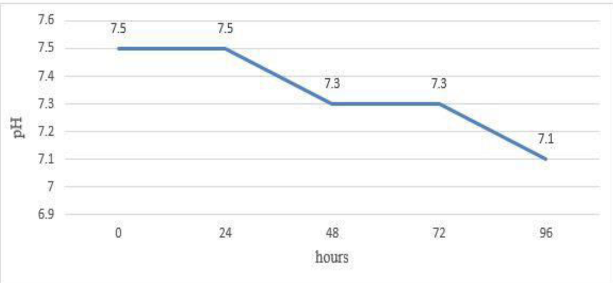

Fig 5.13 Variation in pH of Waste water

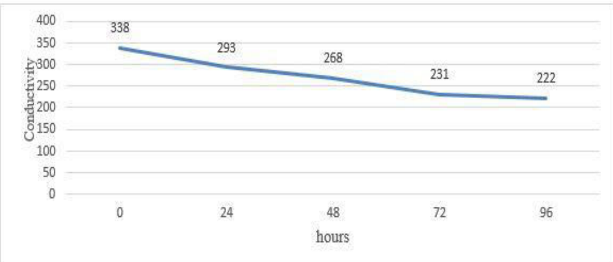

Fig 5.14 Variation in Electrical Conductivity of Waste Water

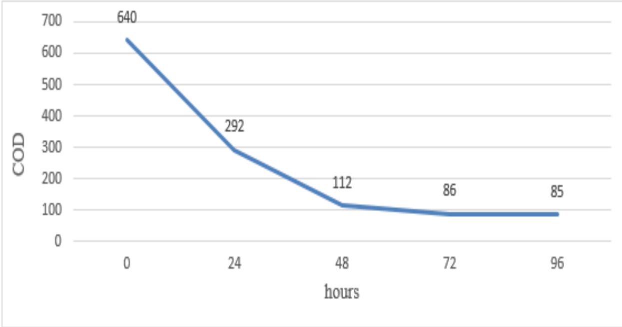

Fig 5.18 Variation in COD of Waste water

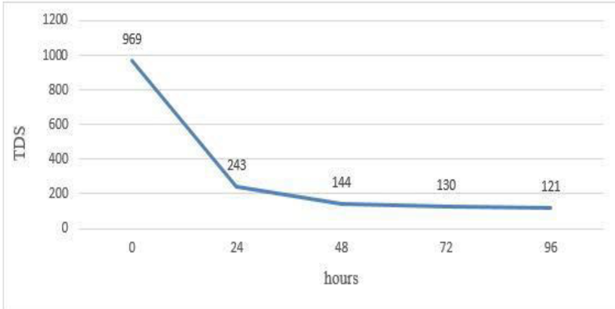

Fig 5.16 Variation in TDS of Waste water

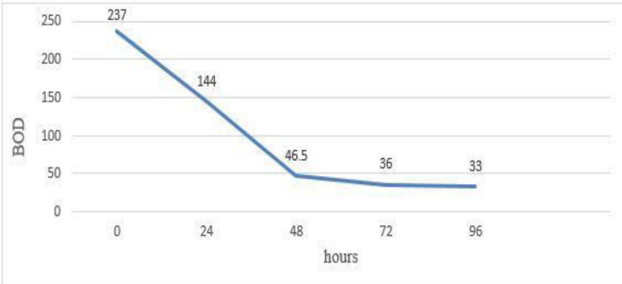

Fig 5.17 Variation in BOD of Waste water

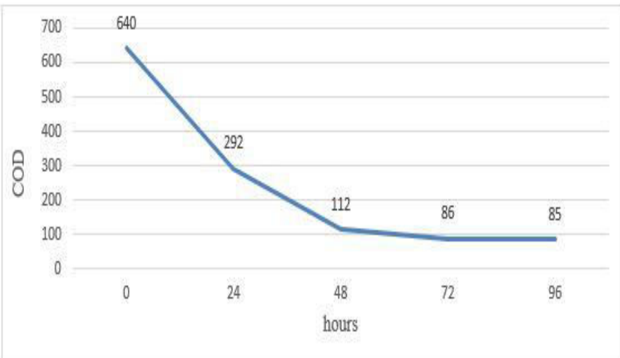

Fig 5.18 Variation in COD of Waste water

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT (IJSREM)
VOLUME: 05 ISSUE: 07 | JULY - 2021 ISSN: 2582-3930

5.1.4 Rose moss plants

Table 5.5 Results Analysed for Removal of Contaminants from Sullage Water

SL NO	Parameters	Raw water	24 hours	48 hour	72 hour	96 hour
1	pH	7.5	7.5	7.1	7.1	7.1
2	Conductivity in µs/cm	338	331	349	261	231
3	TDS in ppm	969	265	142	123	121
4	BOD_5 in mg/L	237	102	49.5	38	21
5	COD in mg/L	640	208	134	102	101
6	Turbidity in NTU	60	41	22.4	13	4
7	Temperature in C	18	18.1	18.1	18.1	18

From table 5.5 and fig 5.19-5.24 it's observed that there was marginal variation in the parameters like pH, TDS, BOD and COD .The analysis of sullage water samples after 24 hours to 96 hours of HRT observed that the pH of the sullage water samples was varying to 7.1 to 7.5. The TDS content of the sample was reduced 969 ppm to 121 ppm. The variation in BOD is 237 mg/L to 21 mg/L. The COD of sample ranged between 640 mg/L to 101 mg/L. The variation in TDS observed was 60 NTU to 4 NTU for 24 hours to 96 hours of treatment respectively. A huge decrease in waste content was seen in sullage water after 96 hours of treatment with the rose moss plant.

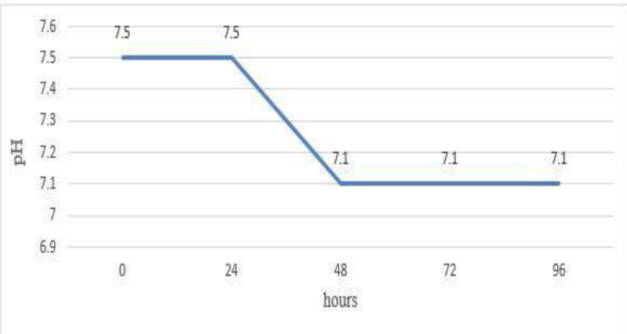

Fig 5.19 Variation in pH of Waste water

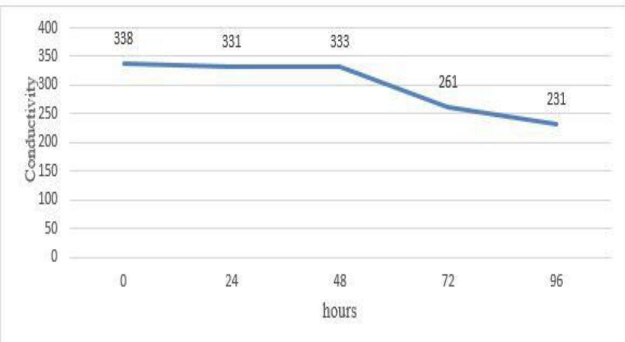

Fig 5.20 Variation in Electrical Conductivity of Waste Water

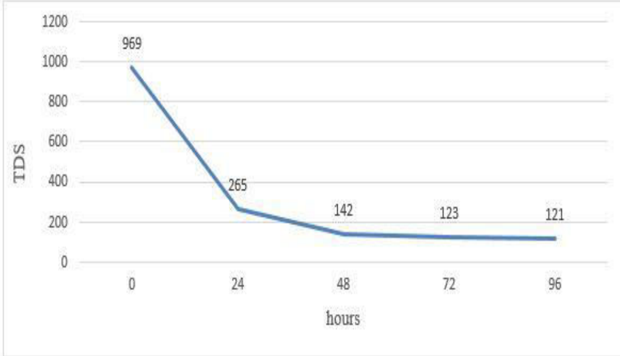

Fig 5.22 Variation in TDS of Waste water

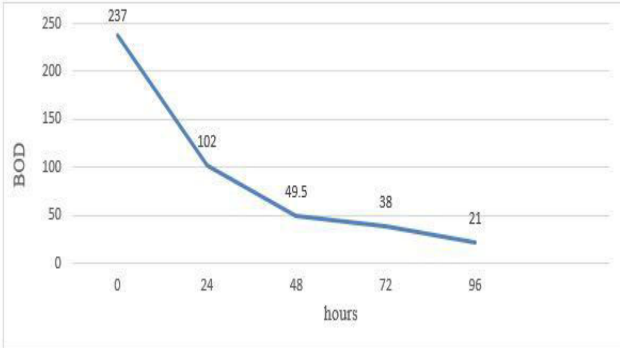

Fig 5.23 Variation in BOD of Waste water

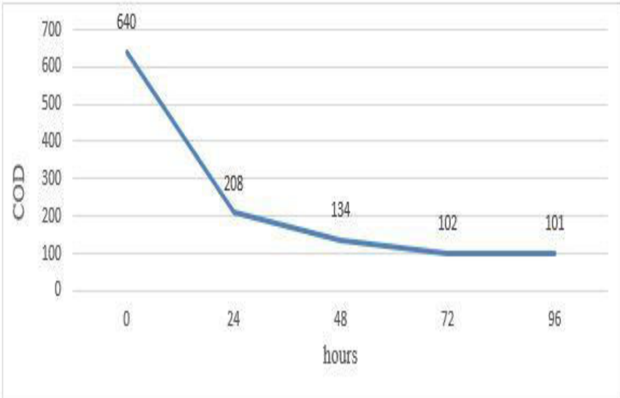

Fig 5.24 Variation in COD of Waste water

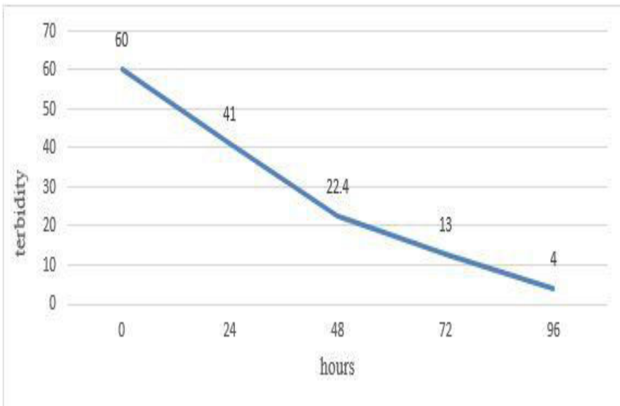

Fig 5.21 Variation in turbidity of waste water

5.1.5 Annual Vinca Plant

Table 5.6 Results Analysed for Removal of Contaminants from Sullage Water

SL NO	Parameters	Raw water	24 hours	48 hour	72 hour	96 hour
1	pH	7.5	7.5	7.1	7.1	7.1
2	Conductivity in ʮs/cm	338	296	276	261	227
3	TDS in ppm	969	554	253	128	111
4	BOD_5 in mg/L	237	133	72	33	29
5	COD in mg/L	640	253	142	102	95
6	Turbidity in NTU	60	29.4	10.2	9	4
7	Temperature in C	18	18.1	18.1	18.1	18

From table 5.6 and fig 5.25 to 5.30 it's observed that there was marginal variation in the parameters like pH, TDS, BOD and COD .The analysis of sullage water samples after 24 hours to 96 hours of treatment observed that the pH of the sullage water samples was varying to 7.1 to 7.5. The TDS content of the sample was reduced 969 ppm to 111 ppm. The variation in BOD is 237 mg/L to 29 mg/L. The COD of sample ranged between 640 mg/L to 95 mg/L. The variation in TDS observed was 60 NTU to 4 NTU for 24 hours to 96 hours of HRT respectively. A huge decrease in waste content was seen in sullage water after 96 hours of treatment with the annual vinca plant.

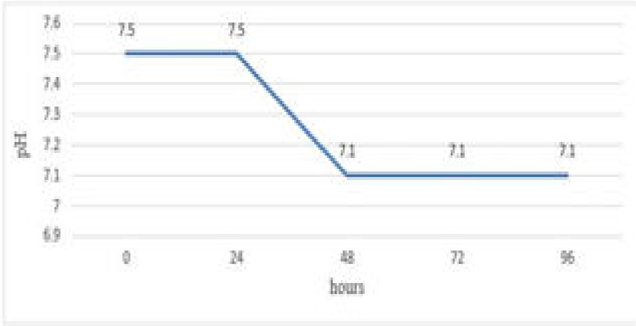

Fig 5.25 Variation in pH of Waste water

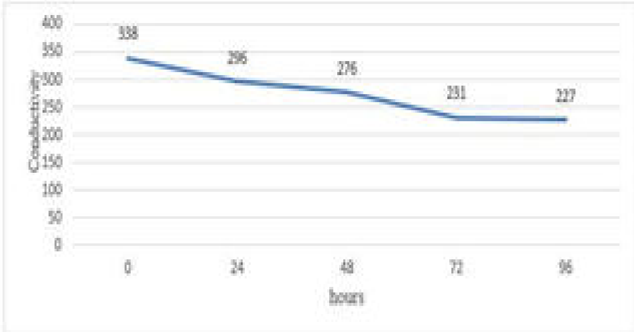

Fig 5.26 Variation in Electrical Conductivity of Waste Water

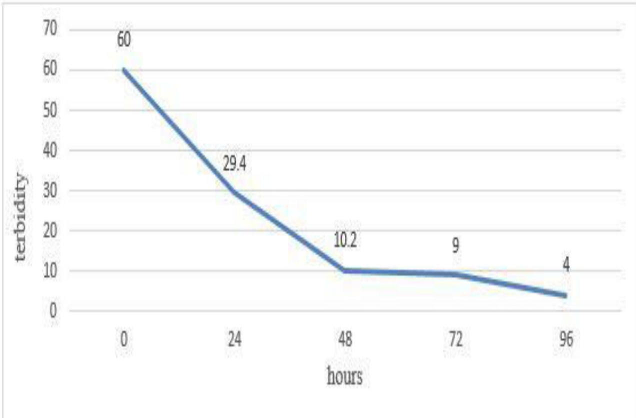

Fig 5.27 Variation in turbidity of waste water

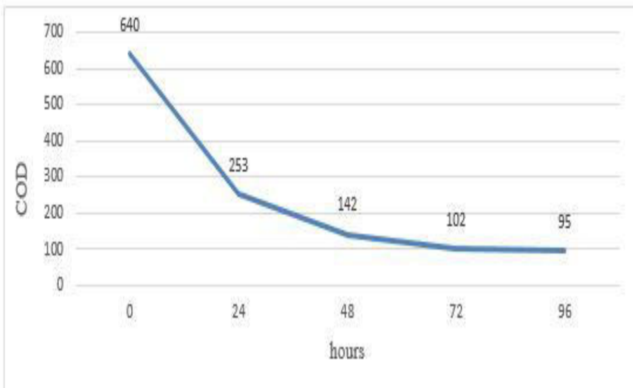

Fig 5.30 Variation in COD of Waste water

ISSN: 2582-3930

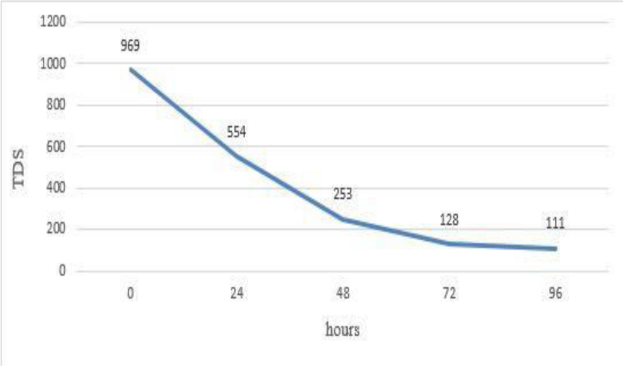

Fig 5.28 Variation in TDS of Waste water

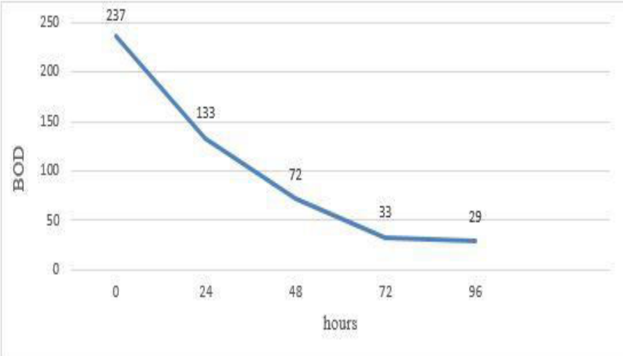

Fig 5.29 Variation in BOD of Waste water

Table 5.7 Comparison between Percentages Removal of Contaminants from plants.

SL NO	PLANT	CONTAMINANT REMOVAL EFFICIENCY IN PERCENTAGE				OVERALL EFFICIENCY
		24 hours	48 hours	72 hours	96 hours	
1	Areca palm	COD -60% BOD- 62.5%, TDS- 73%	COD -80% BOD- 79.1%, TDS- 82.9%	COD -85.1% BOD- 86.0%, TDS- 86.5%	COD -85.1% BOD- 91.1%, TDS- 87.51%	COD -77.55% BOD- 79.67%, TDS- 82.47%
2	Indian Rice plant	COD -65% BOD- 46.83%, TDS- 70.5%	COD -75% BOD- 72.78%, TDS- 86.5%	COD -80% BOD- 82.2%, TDS- 88.2%	COD -84.06% BOD- 82.4%, TDS- 88.7%	COD -76.01% BOD- 71.05%, TDS- 83.47%
3	Grass	COD -54% BOD- 39.2%, TDS- 75%	COD -82.5% BOD- 80.2%, TDS- 85.1%	COD -86.5% BOD- 84.8%, TDS- 86.5%	COD -86.8% BOD- 86.01%, TDS- 87.5%	COD -77.45% BOD- 72.55%, TDS- 83.51%
4	Rose moss	COD -67.5% BOD- 56%, TDS- 72.6%	COD -79.01% BOD- 79.1%, TDS- 85.3%	COD -84.06% BOD- 83.9%, TDS- 87.30%	COD -84.1% BOD- 91.1%, TDS- 87.5%	COD -78.66% BOD- 80.2%, TDS- 83.17%
5	Annual vinca	COD -60.4% BOD- 43.8%, TDS- 42.8%	COD -77.8% BOD- 69.6%, TDS- 73.89%	COD -84.06% BOD- 86.1%, TDS- 86.7%	COD -85.15% BOD- 87.76%, TDS- 88.5%	COD -76.85% BOD- 71.82%, TDS- 72.9%

5.2 Discussions

In case of pH, no significant variations occurred during the phytoremediation operation period. On the whole, pH values showed a trend to be kept on a slightly basic range. These interactions may have resulted in release of salts from the substrate to the water, explaining the slight effect in conductivity, observed along the unit during all time. The average pH values in the influent were 7.5 and in the effluent were 7.3, 7.2 and 7.1 for all plants during the experiment period. Similar results was achieved by Zurita et al. (2009) who reported a 7.7 average pH concentration in the effluent treated.

The average initial reading for TDS was 969 ppm. After phytoremediation treatment duration, 72 hours of treatment considered as optimum, the TDS value was reduced up to 86%, 88.2%, 86.5% 87.3% and 86.7% for the treatment with areca palm, Indian rice plant, grass plant, rose moss plant and annual vinca plant respectively. . TDS is removed due to the filtering action of the bed media. Filtration occurs by impaction of particles onto the roots and stems of the plants or onto the gravel particles in the filter media systems. . Similar results was achieved by Neharika et al. (2015) who reported a 120 mg/L average TDS concentration in kitchen waste water.

The average initial reading for turbidity was 60 NTU. After phytoremediation treatment duration, 72 hours of treatment considered as optimum, the turbidity value was reduced up to 80 % for the treatment with all plants. The turbidity goes on decreasing as the days increasing. The turbid causing substances may get clogged in the pore spaces of the soil as well as gravel media, which in turn will be utilized by the plants. The soil and gravel media acts as a filter and holds the impurities and allows only the clear water effluent to pass through the outlet. Similar studies are carried and comparing results with other studies showed that Rijwana Parwin et al. (2018) observed that turbidity reduction is 51NTU to 9NTU was higher in phytoremediation treatment with Eichhornia crassipes.

The initial reading for BOD was 237 mg/L. After phytoremediation treatment duration, 72 hours treatment considered as optimum, the BOD value was reduced up to 86%, 82.2%, 84.8% 83.9% and 86.1% for the treatment areca palm, Indian rice plant, grass plant, rose moss plant and annual vinca plant respectively. The increase of the number of plants roots, the uptake will increase, because more root surface is available for bacterial growth, and also the plant can absorb more nutrients will allow the increase of dissolved oxygen content results to reduction of BOD of sullage water. According to Chang et al. studied BOD reduction of secondary municipal wastewater treatment with Typha latifolia and Canna indica, in China; they reported 89.3% BOD reduction.

The initial reading for COD was 640 mg/L. After phytoremediation treatment duration, 72 hours treatment considered as optimum, the COD value was reduced up to 85.1%, 80%, and 86.5% 84.06% and 84.06% for the treatment areca palm, Indian rice plant, grass plant, rose moss plant and annual vinca plant respectively. The reduction in COD was obtained because the plants underwent the process of photosynthesis. The photosynthesis activity increases the dissolved oxygen in water, thus creating aerobic conditions in wastewater in favour of aerobic bacterial activity to reduce COD contents. Similar studies are carried and Comparing results with other studies showed that the range of COD reduction is between 16.5 and 98%, for different types of wastewater and plants.

6. CONCLUSIONS

- **Areca palm plant:** Areca palm plant is ornamental outdoor plant commonly used for gardening purpose. During the experiment, it was observed that removal of COD, BOD5, and TDS are reduced and 72 hours of treatment was considered as optimum. The removal efficiency of 72 hours of treatment is 85.1%, 91.1% and 87.5% respectively.
- **Indian rice plant**: Rice is the seed of the grass species and its agriculture crop grows commonly in agriculture land. It is heat and water loving plant, requiring high temperature and adequate moisture supply. During the experiment, it was observed that removal of COD, BOD5, and TDS are reduced and 72 hours of treatment was considered as optimum. The removal efficiency of 72 hours of treatment is 80%, 82.2% and 88.2% respectively.
- **Grass plant:** Grass is garden plant grow up to 9 inch needs adequate amount of water to grow. It spread like a bed on the land. . During the experiment, it was observed that removal of COD, BOD5, and TDS are reduced and 72 hours of treatment was considered as optimum. The removal efficiency of 72 hours of treatment is 86.5%, 84.8% and 86.5% respectively.
- **Rose moss plant:** Rose moss is ornamental flower plant grows outdoor. . During the experiment, it was observed that removal of COD, BOD5, and TDS are reduced and 72 hours of treatment was considered as optimum. The removal efficiency of 72 hours of treatment is 84.06%, 83.9% and 87.30% respectively.
- **Annual vinca plant:** annual vinca also called periwinkle plant its ornamental garden plant. During the experiment, it was observed that removal of COD, BOD5, and TDS are reduced and 72 hours of treatment was considered as optimum. The removal efficiency of 72 hours of treatment is 84.06%, 86.1% and 86.5% respectively.
- Phytoremediation process performed in 1, 2, 3 and 4 days Hydraulic Retention Time, for all plants the average removal efficiency were obtained as follows 80% reduction in BOD , 79 % reduction in COD and 83 % reduction in TDS
- The study determined that, rose moss plant is optimum with 72 hours hydraulic retention time is best with overall efficiency of 81 %.
- Rose moss plant is a good option for plantation in the development of Phytotechnology system because it is easy to grow in any local climatic condition and more decontamination efficiency.
- Phytoremediation required lesser energy, are easily operated, have no sludge disposal problems and can be maintained by untrained personnel.
- From the study it can be concluded that, the use of plants for removing of contaminants from waste water is cost effective and involving very less operation and maintenance work.

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