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Bioremediation of Industrial Wastewater by Algae: A n Experimental Study

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Abstract: This paper summarizes the ill-effects of discharge of industrial effluents containing toxic heavy metals such as copper(Cu) and zinc(Zn),Cadmium, nickel chromium, arsenic into the environment. Also the project illustrates serious impact on human, animal and aquatic life. In solve these problems the project study was focused on evaluating and demonstrating potential of microalgae for bioremediation of wastewater. The test of wastewater samples collected from CETP treatment plant were carried out using filamentous microalgae, *Cladophora* which was available from Discharge Point of Treated wastewater RELIANCE at VECL (Dhanora, Vadodara). To test the sample collected for various contaminants proportion, various mixes of that sample was prepared.

The viability of the process was demonstrated in laboratory bioreactors and various experimental parameters such as pH, TDS, COD Chloride, Zinc, Copper, Nickel, Cadmium were measured.

Keywords: Bioremediation, Wastewater, Micro algae, Heavy metal.

1. INTRODUCTION

The present scenario of reduction in the fresh water resource availability in the world is getting severe. It is certainly a special challenge to solve the water resource issues and problems in developing countries, even though when the one third part of the earth surface is covered with water. **[2]**

The major reason of this issue is population expansion and industrial development. These are the reason behind deterioration of the quality of freshwater reservoirs around the world and has caused freshwater shortages in certain areas. According to U.S. geological survey, it is projected that by the year 2025 global water demand will exceed supply by 56%.

The major challenges to water quality does not stem only from the physical contaminants themselves but also from the sheer volume of contaminants that is overwhelming an area's infrastructure or resources to treat and remove the contaminants.

To solve this water crisis and to meet the growing population's demand for freshwater, wastewater treatment techniques aimed at remediating wastewater should be employed. **[4]**

So, the project study is carried out to remediate atleast half volume of the wastewater generated daily which is expected, to provide a solution for water crisis. Different industries produce various kinds of industrial wastewater based on their own specific combination of pollutants. Among those, metal working industry serves as an important pollution contributor. This is because it discharges heavy metal waste (toxic waste) such as nickel, lead, chromium, cadmium, zinc and iron contaminated wastewater into the environment. This unprocessed disposal of industrial and domestic wastes leads to heavy pollution of water, threatening all kinds of inhabiting organisms. Therefore, it is necessary to focus on the treatment techniques and ways to partially remove contaminants (heavy metals) from wastewater before discharging them into waterways. **[11]**

Remediation techniques are emerging as effective and affordable alternatives to remove heavy metals like copper, zinc, lead, etc., from soil and water systems. Literature shows that aquatic plants like water hyacinth (lead and cadmium), duckweed (arsenic), aquatic ferns (arsenic), green algae (copper and zinc) can effectively remove dissolved heavy metals [13,2,3]. Also the biosorption potential of algal species like Spirulina platensis, Cystoseria indica, Anabaena variabilis and Nostoc muscorum for metal ions like arsenic, lead, chromium, cadmium, uranium and dyes are extensively being reported. **[5]**

2. EXPERIMENTAL EQUIPMENTS AND MATERIALS

Following were the experimental materials used for the research work.

Apparatus- pH Meter, Epoxy coated Glass Electrode, Evaporating dishes, Analytical balance, Filter Paper, COD Digestion, Conical Flasks, Burette, Pipette, Funnels , Dispensers, Pipettes, pipettes, Micropipettes, Hot plate, Beakers, Hand-gloves Acid Alkali proof, 20L Capacity bucket.

Chemicals- Potassium Dichromate ($K_2Cr_2O_7$), Silver Sulphate (Ag_2SO_4), Conc. Sulfuric Acid, Ferrous Ammonium Sulphate, Mercuric Sulphate ($HgSO_4$), Potassium Di-Chromate $K_2Cr_2O_7$, Silver nitrate, Sodium chloride solution, Boric acid, Mixed Indicator, Conc. HNO_3,

Wastewater-The tests were conducted on a wastewater sample which was obtained from CETP (Common Effluent Treatment Plant) at Nandesari,Vadodara,Gujarat,India.

Selection of Algae-The Filamentous Algae *Cladophora* was collected from Treated wastewater discharge point of RELIANCE Industry at VECL(Vadodara Enviro Channel Limited,Dhanora,Vadodara). Algae was collected in cans and washed thoroughly with tap water and placed in the respective set up for the experimental study. Algae species were identified at Environment Science Laboratory of MSU, Vadodara.

3. METHODOLOGY AND EXPERIMENTAL WORK

The experiments were conducted to examine the various contaminants present in the sample mixes prepared and their proportions.

Various Mixes of Wastewater Sample:

Different Mixture type	Ratio of Mixture Wastewater (%)
Mixture A	10% (1L CETP + 9L RIL)
Mixture B	30% (3L CETP + 7L RIL)
Mixture C	50% (5L CETP + 5L RIL)
Mixture D	100% (10L CETP wastewater)

Procedure:

(a) The wastewater of about 10 litres was fed into the rectangular plastic bucket of 35 x 25 x 18 cm size. **[6]**

(b) The bucket was operated at atmospheric temperature with sun light at day.

(c) Initial dosage of Algae 100 gm was fed to the reactor. **[7]**

(d) The dosage was applied to the combination of various mixes of wastewater sample prepared.

Optimization of sample:

The wastewater was fed to the bucket containing 100 gm of algae. No pH adjustment was made. Then at every 3rd day samples were collected and analysed at VECL Laboratory for the various parameters like pH, TDS, Chloride, COD, Heavy Metal like Zinc, copper, Nickel, cadmium.

Results and Discussion:

Results of the sample Mixture A including- 10 L (9 L Reliance water + 1L CETP):

Table 1: Concentrations of Elements in Wastewater Sample Mixture A-10 L (9L Reliance Water + 1L CETP)

Sr No	Parameters	Unit	0th Day	3rd Day	6th Day	9th Day	12th Day	15th Day
1	pH		7.15	7.45	7.83	8.1	8.31	8.35
2	TDS	mg/L	7610	8050	8230	8180	8540	8940
3	COD	mg/L	183	150	123	57	93	130
4	Chloride	mg/L	3230	3420	3280	3630	3320	3710
5	Zinc	mg/L	0.407	0.32	0.28	0.08	BDL	BDL
6	Copper	mg/L	0.81	0.78	0.46	0.10	BDL	BDL
7	Nickel	mg/L	0.13	0.20	0.15	0.1	0.1	0.15
8	Cadmium	mg/L	0.019	BDL	BDL	BDL	BDL	BDL

Results of the sample Mixture B including - 10 L (7 L Reliance water + 3 L CETP):

Table 2: Concentrations of Elements in Wastewater Sample Mixture B-10 L (7L Reliance Water + 3L CETP)

Sr No	Parameter	Unit	0th Day	3rd Day	6th Day	9th Day	12th Day	15th Day
1	pH		7.01	7.52	7.89	7.93	8.2	8.35
2	TDS	mg/L	12300	13225	12800	13552	12890	12720
3	COD	mg/L	280	310	295	234	197	178
4	Chloride	mg/L	4800	5125	4987	4875	4620	4582
5	Zinc	mg/L	1.121	0.88	0.67	0.21	0.13	BDL
6	Copper	mg/L	2.61	2.32	1.68	1.18	0.87	BDL
7	Nickel	mg/L	0.18	0.15	0.20	0.18	0.12	0.16
8	Cadmium	mg/L	0.1	0.08	BDL	BDL	BDL	BDL

About 100gms of wet Algae was inoculated in the **C**. 10 L (5L reliance water + 5L CETP) wastewater and **D**. 10 L (10 CETP wastewater) in a plastic tray of 20 L capacity separately. The tray was kept open in direct sunlight at Day and provided artificial light (2500 lumens) at Night. Every 3rd day the growth of algae is observed and the sample of water is analysed.

Results of the sample Mixture C including- 10 L (5 L Reliance water + 5 L CETP):

Table 3: Concentrations of Elements in Wastewater Sample Mixture D-10 L (5L Reliance Water + 5L CETP)

Sr No	Parameter	Unit	0th Day	3rd Day	6th Day	9th Day	12th Day	15th Day	Standard Limit
1	pH		7.11	7.78	7.94	8.01	8.19	8.31	6.50 to 8.5
2	TDS	mg/L	24200	25630	25877	26136	26422	26709	5000
3	COD	mg/L	1721	1255	1150	843	613	473	250
4	Chloride	mg/L	9803	9890	9950	10059	10178	10289	600
5	Zinc	mg/L	1.988	1.56	0.83	0.32	0.08	BDL	5
6	Copper	mg/L	5.80	3.91	2.73	0.97	0.57	0.51	3
7	Nickel	mg/L	0.72	0.70	0.73	0.59	0.62	0.60	3
8	Cadmium	mg/L	0.09	0.08	BDL	BDL	BDL	BDL	2

Results of the sample Mixture D- 10 L (10L CETP):

Table 4: Concentrations of Elements in Wastewater Sample Mixture D-10 L (10L CETP)

Sr No	Parameter	Unit	0th Day	3rd Day	6th Day	9th Day	12th Day	15th Day	Standard Limit
1	pH		6.86	6.95	7.13	7.52	7.72	7.97	6.50 to 8.5
2	TDS	mg/L	44140	44390	44530	44955	45124	45357	5000
3	COD	mg/L	3400	3152	2641	1921	1412	927	250
4	Chloride	mg/L	21328	21620	22100	22497	22836	23238	600
5	Zinc	mg/L	4.18	3.28	1.88	0.97	0.39	0.08	5
6	Copper	mg/L	9.38	6.52	4.89	1.80	0.92	0.72	3
7	Nickel	mg/L	1.185	1.171	1.181	1.179	1.178	1.182	3
8	Cadmium	mg/L	0.205	0.18	0.095	0.021	BDL	BDL	2

4. RESULTS AND DISCUSSION

Following are the results for different parameters like pH, TDS, COD, Chloride and heavy metals of different Mixtures of wastewater which has been derived from the experimental work.

1) pH Variation

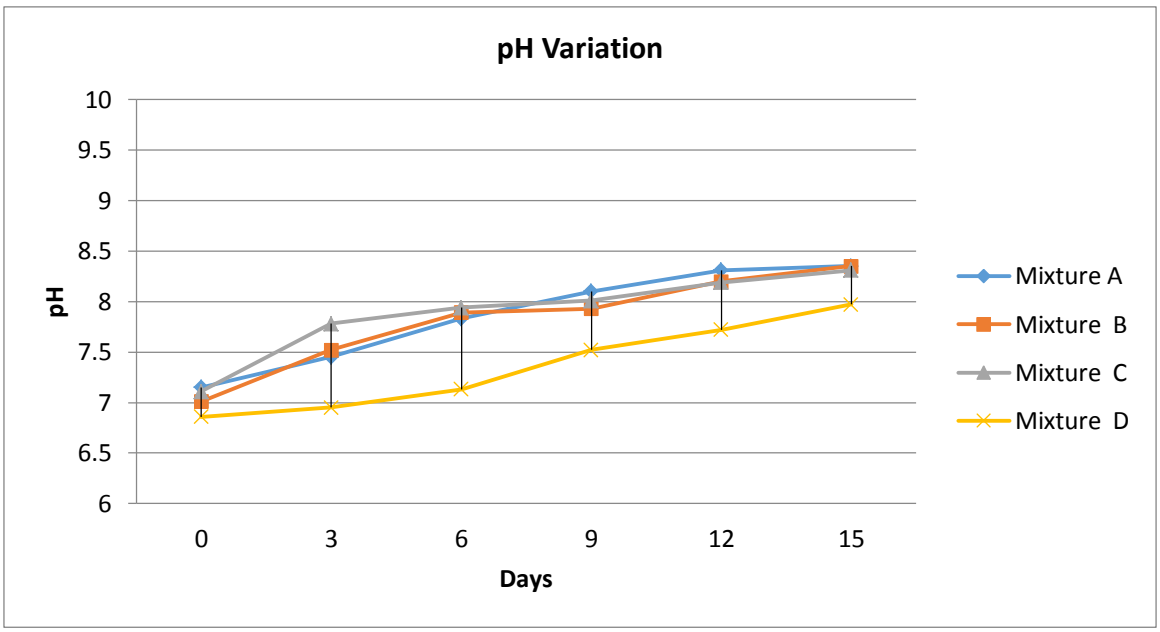

Figure 1 pH Variation in Mixtures

As shown in the fig, the pH was increasing in a little proportion for various mixtures when tested at different time duration.

2) TDS Variation

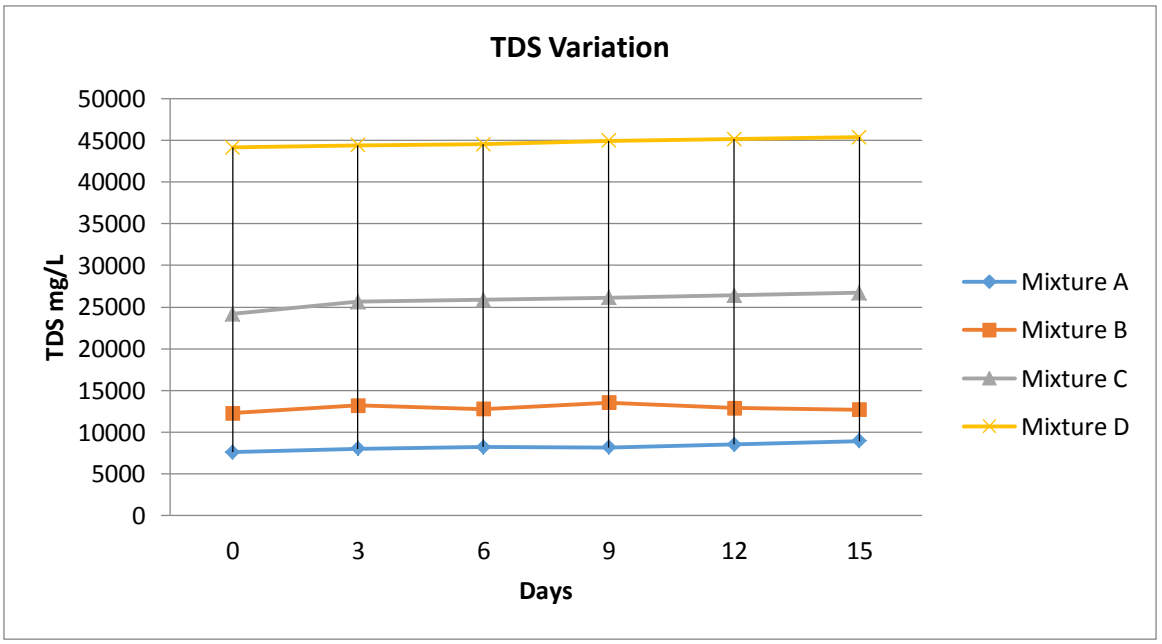

Figure 2 TDS Variation in Mixtures

As shown in the graph, the TDS was increasing in a little proportion for various mix when tested at different duration. For example : TDS concentration at 0 day means initially was 7610 mg/L was increased upto 8940 mg/L at the end of 15th day by remediating the sample mix with *Cladophora* algae in proper proportion.

3) Removal of COD

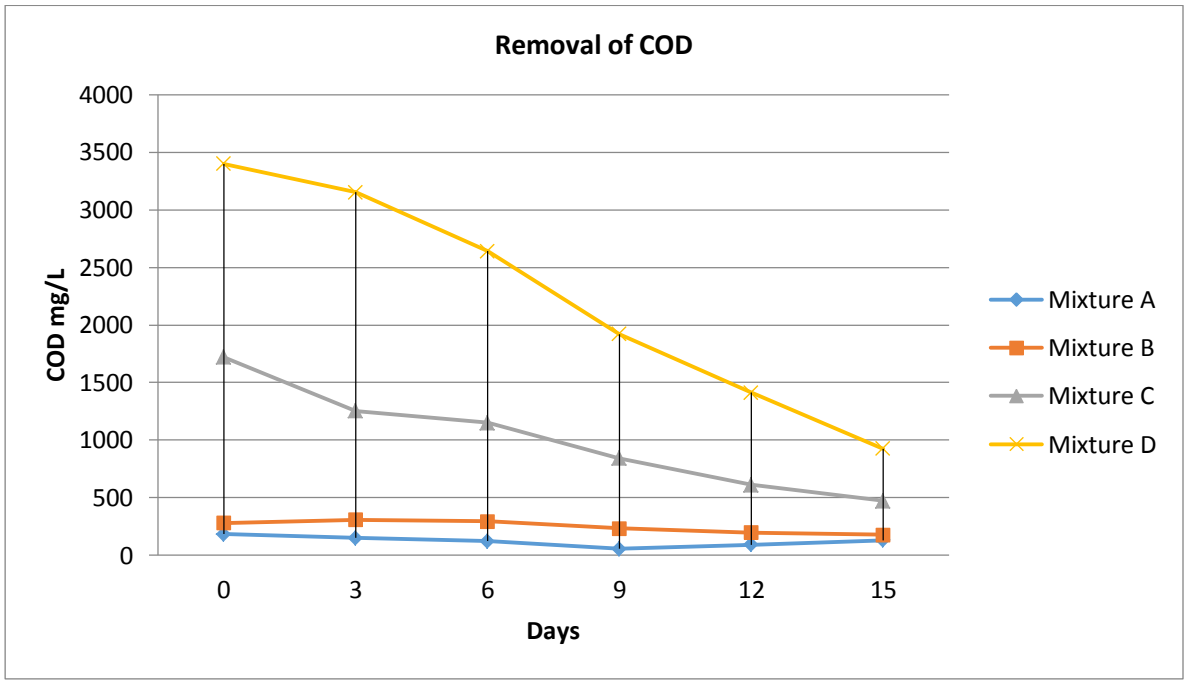

Figure 3 COD Removal in Mixtures

As shown in the graph, the COD was considerably reduced for various mix when tested at different duration.at the end of 15th day by remediating the sample mix with *Cladophora* algae in proper proportion.

4) Chloride Variation

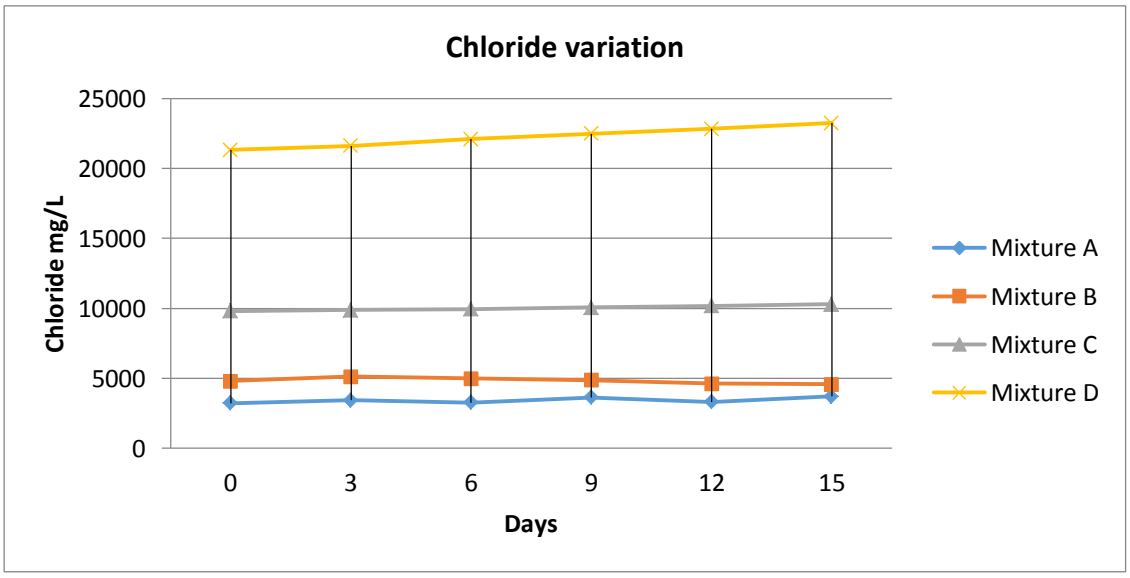

Figure 4 Variations in Chloride in Mixtures

As shown in the graph, the chloride content was increasing in a little proportion for various mix when tested at different duration. For example: Chloride concentration at 0 day means initially was 3230 mg/L was increased upto 3710 mg/L at the end of 15th day by remediating the sample mix with Cladophora algae in proper proportion.

5) Zinc Removal

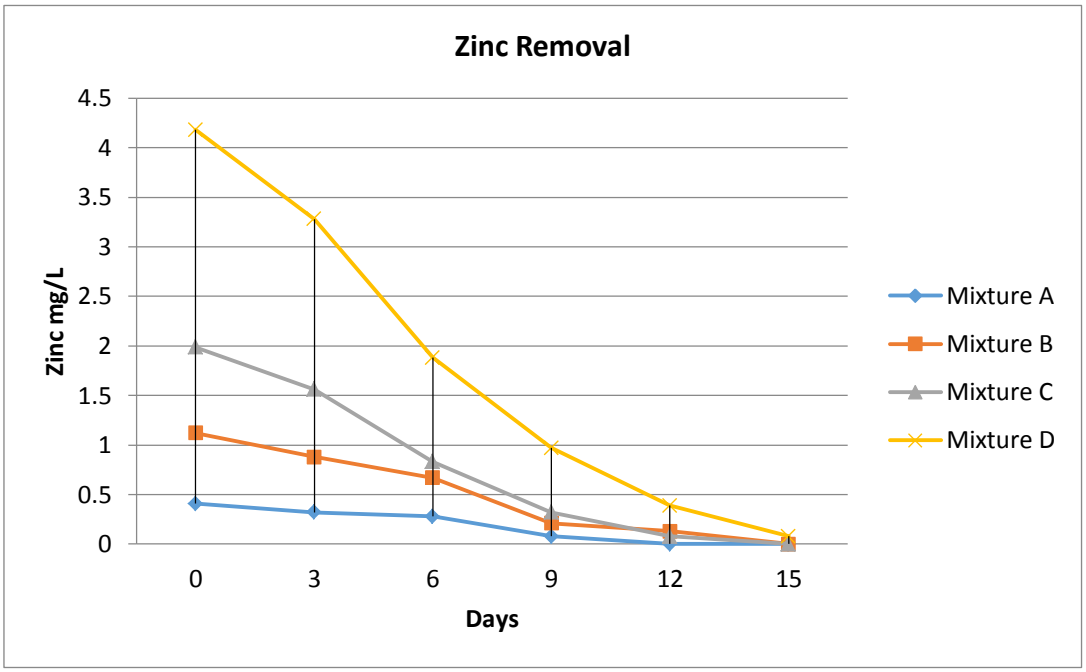

Figure 5 Zinc Reduction in Different Mixtures

As shown in the graph, the zinc was considerably reduced for various mix when tested at different duration. For example : Zinc concentration at 0 day means initially was 0.407 mg/L was reduced upto BDL at the end of 15th day by remediating the sample mix with Cladophora algae in proper proportion.

6) Copper Removal

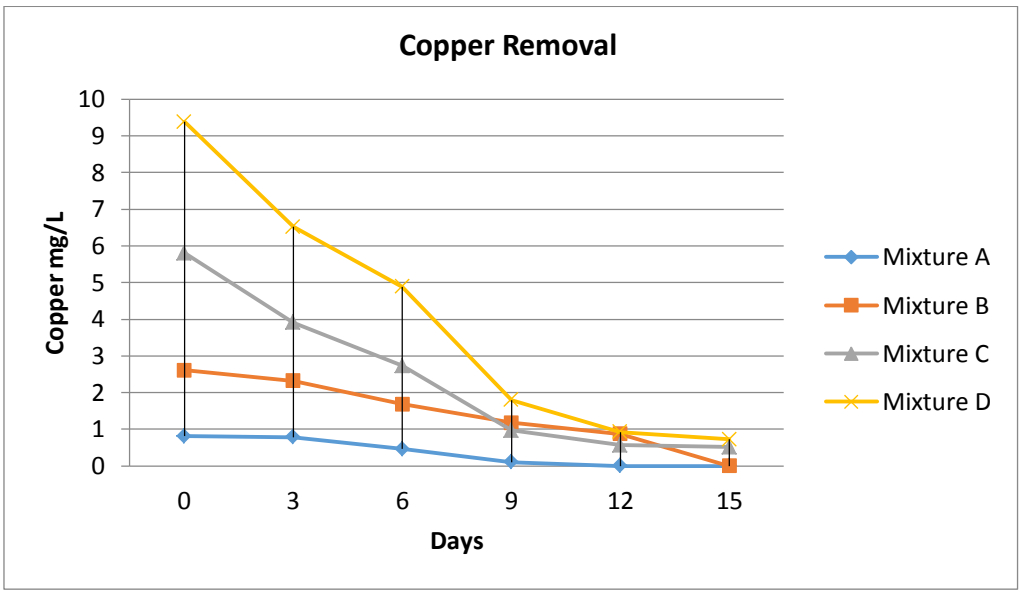

Figure 5 Copper Reduction from Mixtures

As shown in the graph, the Copper was considerably reduced for various mix when tested at different duration. For example : Copper concentration at 0 day means initially was 0.819 was reduced upto BDL at the end of 15th day by remediating the sample mix with Cladophora algae in proper proportion.

7) Nickel Removal

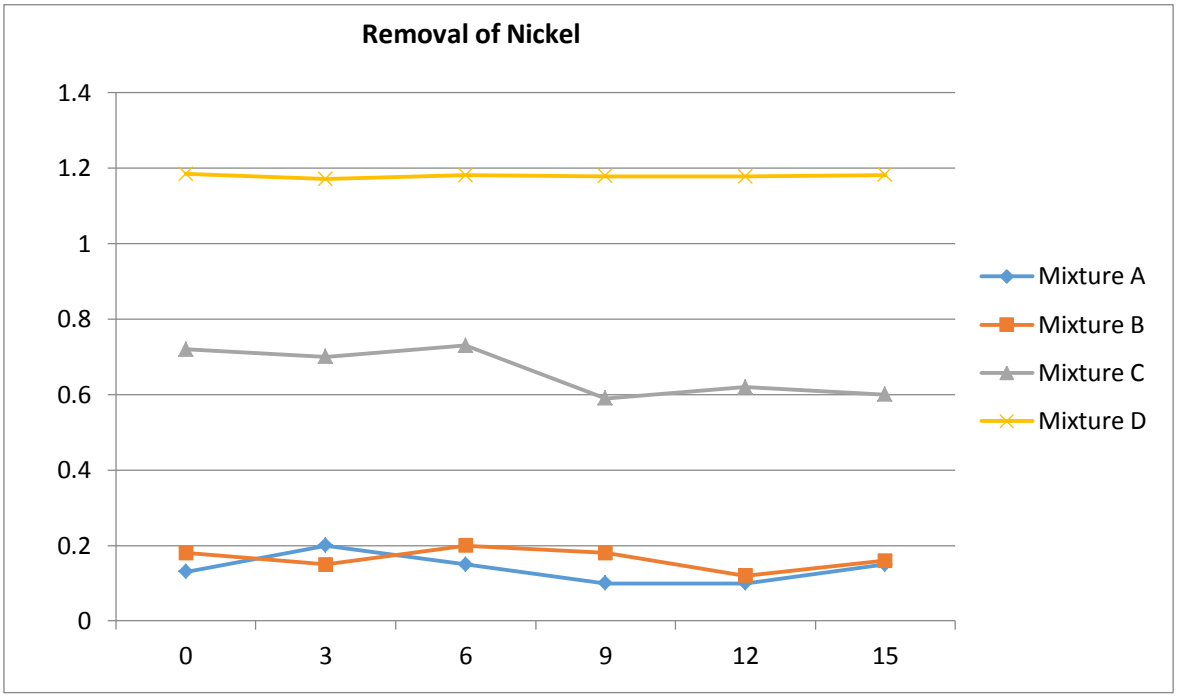

Figure 7 Variation in Nickel reduction for Mixture

As shown in the graph, the Nickel was increased a little for various mix when tested at different duration. For example : Nickel concentration at 0 day means initially was 0.13 was increased upto 0.15 at the end of 18th day by remediating the sample mix with *Cladophora* algae in proper proportion.

8) Cadmium Removal

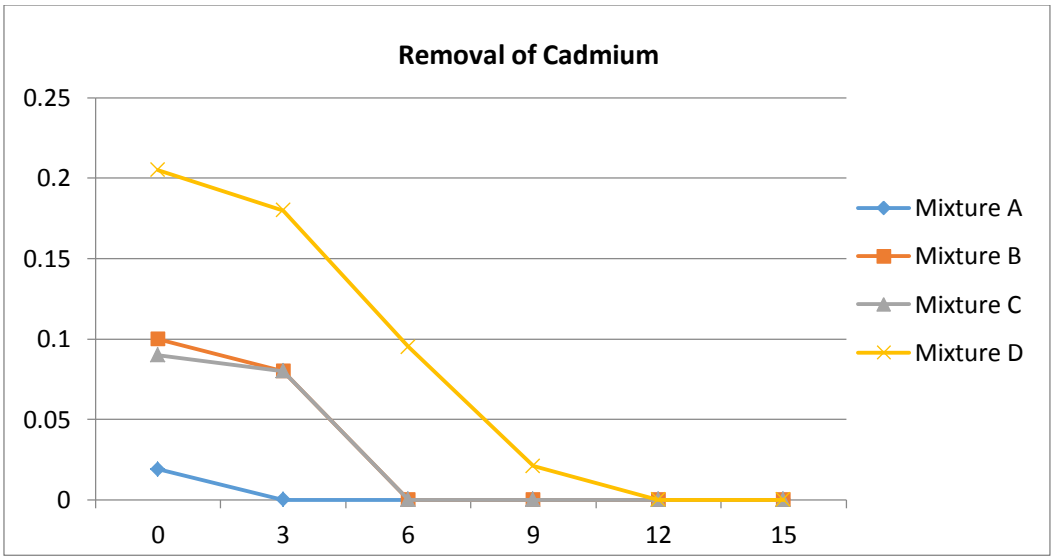

Figure 8 Cadmium Reduction from Mixtures

As shown in the graph, the Cadmium was considerably reduced for various mixture when tested at different duration. For example : Cadmium concentration at 0 day means initially was 0.019 mg/L which was reduced upto BDL at the end of 15th day by remediating the sample mix with *Cladophora* algae in proper proportion.

5. CONCLUSIONS

From the above experimental test, following conclusion is drawn:

The present work evaluated the potential of green algae for the bioremediation of industrial effluent. The results obtained in this study indicated the highest adsorption ability of Cladophora sp. for Cu, Zn, and COD also. Thus, the use of green algae for the development of efficient bioremediation can be considered an eco-friendly and cost-effective approach for heavy metal removal.

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