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METALS, NUTRIENTS AND COD REMOVAL BY FRESH AND MARINE WATER ALGAE (SEA WEEDS)

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ABSTRACT

Several materials were used as adsorbents to remove metal ions and other hazardous pollutants from aqueous environments, however natural sources are considered ecological safer, cheaper, and more efficient than physicochemical processes. Marine algal biomass has proven to be highly effective as well as reliable and predictable in the removal of Pb^{+2}, Cu^{+2}, Cd^{+2}, and Zn^{+2} from aqueous solutions. Fresh water algae, *Chara* and *Oedogonium and* marine water algae, *Ulva lactuca, Scinaia furcellata, and Caulerpa racemosa* were used for the biosorption study of some heavy metals for live algae was estimated. COD and adsorption isotherms were observed and found that the adsorption of Cr^{+6}, Al^{+3} and Fe^{+3} ions at 50ppm and 100 ppm found maximum by *Chara, Ulva lactuca, and Caulerpa show maximum* adsorption, respectively. In batch reactor studies, *Oedogonium shows* approximately 78% removal efficiency for chromium ion removal.

Keywords: Biosorption, Algae, Heavy metal, Batch reactor, COD

INTRODUCTION

The presence of large quantities of toxic metals poses serious threat puts the scientific community under pressure to develop new methods to detect and eliminate toxic contaminants from wastewater in efficient and economically viable ways [1]. Most heavy metals are well known toxic and carcinogenic agent

and when discharge into the wastewater represents a serious threat to the human population and the fauna and flora of receiving water bodies.

Many pollutant sources in wastewater are reported as food sources for algae. Algae consume large quantities of nitrates and phosphates to support their fast cell cycle. For normal functioning of algae some heavy meats including iron (for photosynthesis) and chromium (for metabolism) play important role. The uses of algae have several advantages over normal bacteria-based bioremediation. The removal of pollutant by bio absorbance does not need oxygen under lightcondition [2]. Bio absorbance technologies for removal of heavy metals from aqueous solution are more economical and releases least wastes. Microalgae have been recognized as suitable vector for detoxification and have emerged as a potential low-cost alternative to physicochemical treatment [1, 3]. Nonviable cells have also been used successfully in metal removal at contaminated sites. Some of the technologies in heavy metal removal, such as High-Rate Algal Pond (HALP) and Algal Turf Scrubber, have been justified for some practical application in China and abroad and limitations of these methods in large scale still exist [4, 5].

As an innovative clean-up technology, it mainly depends on the bio sorption and bioaccumulation abilities of algae. Available biosorbents (i.e., fungi, bacteria, and yeasts) recently investigated for their ability to sequester heavy metals, brown algal biomass has proven to be highly effective as well as reliable and predictable in the removal of, for example, Pb^{+2}, Cu^{+2}, Cd^{+2}, and Zn^{+2} from aqueous solutions. Some reviews that deal with biosorption by different types of biomass [6].

Phosphorous and nitrogen are the main nutrients encouraging the growth of organic matter and algae which cause eutrophication in water bodies. Conventional technology like activated sludge, a biological floc, to degrade organic carbonaceous matter to CO_2 has been widely applied in wastewater treatment. The process removes most of the organic contaminants, nitrogen (N) and phosphorus (P) in the wastewater. However, the secondary effluent still contains high level of N and P, which may cause eutrophication.

Algae can utilize nitrogen and phosphorus from wastewater for their growth and can assimilate organic pollutants into cellular constituents such as lipid and carbohydrate, thus achieving pollutant reduction in a more environment-friendly way.Moreover, it can also fix carbon dioxide from

atmosphere as in photosynthesis, thus reducing greenhouse gas emission [7]. During the day algae picks up carbon dioxide and releases oxygen through photosynthesis so the dissolved oxygen in the water rises. At night, their metabolism requires them to take up oxygen and release carbon dioxide. These fluctuations can be large [8].

The main objective of the present research was to remove metals, COD, and nutrients by various algal species. Metal and nutrient removal efficiency and tolerance were also assessed by performing kinetic study and by various isotherms. Metal adsorption capacity and removal efficiency by using algae was carried out in batch and continuous reactor studies.

MATERIALS AND METHODS

Collection and cultivation of algae

Different cultures of fresh water and marine water algae were collected from Okha port (marine algae) and Verakhadi (freshwater algae) to check removal efficiency of various metals, COD, and nutrients. Marine water algae were cultivated in Erd-Schreiber's medium [9] and freshwater algae were cultivated in the Bold Basal Medium. Reagents such as sodium nitrate, magnesium sulfate, sodium chloride, potassium phosphate, calcium chloride EDTA, potassium hydroxide etc were procured from Hi-Media of AR grade. In present study different algal species used:

1) Freshwater algae: *Chara (*from Verakhadi) and *Oedogonium* (from Karamsad lake) 2) Marine water algae: *Ulva lactuca, Scinaia furcellata* and *Caulerpa racemosa* (From Okha port).

Estimation of metals and nutrients

The concentration of metals Cr, Fe, Al; and nutrients like nitrogen and phosphorous were determine at different time interval by using colorimetric spectroscopy by ensuing the methods as described in APHA, 2005. For the determination of metals, the biomass and other debris were removed by centrifuging at 5000 rpm for 10 min and supernatant was collected for subsequent estimation of metal concentration.

Assessment of bio-sorption efficiency of chromium, aluminium and iron by live algae

To estimate metal dependant metal removal efficiency, 50 ml system of 50ppm and 100ppm chromium solution was prepared, and 2.5 g of different fresh water and marine algae were added and incubated at room temperature in sunlight. Then standard procedure of chromium estimation was carried out at 6 hours, 24 hours, and 48 hours incubated samples. To maximize chromium removal by algae, column experiment was conducted, and similar conditions were followed, and column was filled with freshwater algae and known concentration of chromium solution was applied and sampling was done at regular

interval by following the above procedure Aluminium and iron concentration were determined by Eriochrome cyanine R method and Phenanthroline method, respectively [10].

Estimation of nitrite nitrogen, ammonical nitrogen

Nitrite ion (NO_2^-) as nitrous acid reacts with sulphanilamide to form diazonium salt which combine with N (1-napthyl ethylenediamine dihydrochloride (NEDA) to form bright pink colour azo dye. The colour reduction is directly proportional to concentration of nitrite nitrogen in sample. The colour obeys beer's law up to 180ppm with 1 cm light path at 540 nm. Ammonical nitrogen was determined by phenate method [10]. Alkaline phenol and hypochlorite react with ammonia to form indophenol blue that is proportional to the ammonia concentration, intensity of blue colour was measured at 640nm.

Estimation of inorganic phosphate, Total phosphorus, and Organic phosphorus

Inorganic Phosphate was estimated by converting orthophosphate into molybdophosphoric in acidic conditions with ammonium molybdate further reduced by stannous chloride to a blue coloured complex. The intensity of blue colour is measured at 690nm, which is directly proportional to the concentration of phosphate present in sample [10].

All the form of Phosphorus, whether dissolve or particulate are converted to inorganic form (phosphate) after digestion of sample using H_2SO_4-HNO_3 digestion technique. After taking appropriate portion of digested sample and precede the same procedure for estimation of inorganic phosphorous as mentioned above.

Estimation of Organic phosphorus

Organic phosphorus can be obtained as difference between the total phosphorus and inorganic phosphorus of sample.

Organic phosphorus = Total phosphorus - Inorganic phosphorus

Measurement of COD (Chemical Oxygen Demand)

COD determines the amount of oxygen required under specific test conditions for the oxidation of waterborne organic and inorganic matter. The organic matter and oxidisable inorganic substance present in water or wastewater get oxidised completely by standard potassium dichromate ($K_2Cr_2O_7$) in the presence of H_2SO_4 to produce CO_2 and H_2O. The excess $K_2Cr_2O_7$ remaining after the reaction is titrated with ferrous ammonium sulphate [$Fe(NH_4)_2(SO_4)_2$] [10]. The dichromate consumed gives the O_2 required for oxidation of the organic matter. The contents are reflux for 2 hours.

Column experiment

A glass column was used to study column experiment (Batch reactor study) for the

Chromium removal by using same algae. Experiment was conducted to check the reusability of bio-sorbent. Column was filled with the known quantity of algae to provide biosorbent bed. 100ppm and 200ppm Cr containing solutions were applied inside the column. At different time interval effluent was collected from the column outlet and analysed for the chromium concentration.

Removal efficiency of metal by species of algae was calculated by using following formula.

$$\text{Removal efficiency}(\%) = \frac{[(C_o - C_e).\mathbf{100}]}{C_o}$$

The amount of metal absorbed per unit mass was calculated as:

$$Qe = \frac{[(C_o - C_e).V]}{m}$$

Where, Qe is metal uptake by the adsorbent(mg/g), Co is the initial concentration of the metal(ppm), Ce is final concentration of the metal in effluent(ppm), V is the volume of the solution(ml) and m is the weight of algal biosorbent(g).

Adsorption isotherm

Adsorption can be described through isotherms, i.e., functions which connect the amount of adsorbate, on the adsorbent. Distribution of metal ions between the liquid and solid phase can be described by isotherm model such as Langmuir and Freundlich.

Langmuir adsorption model

This isotherm assumes monolayer adsorption onto a surface containing a finite number of adsorptions onto a surface containing a finite number of adsorption sites. Once a site is filled, non-further sorption can take place at that sits. This indicates that the surface reaches a saturation point where the maximum adsorption of the surface will be achieved. The saturated monolayer isotherm is represented as:

$$q_e = K_L.q_m. Ce/ (1+K_L.C_e)$$

Where q_e is metal ion absorbed per unit mass(mg/g), Ce is equilibrium concentration (mg/L), q_m is maximum adsorption capacity(mg/g) and K_L is an affinity constant or Langmuir adsorption constant. The linear plot of specific adsorption (C_e/q_e) against the equilibrium concentration (C_e) shows adsorption obeys the Langmuir model and the values of the K_L and q_m can be calculated from the graph. Value of R_L give idea about the type of the Isotherm calculated as follow:

$$R_L = 1/ (1+b.C_o)$$

If $R_L > 1$ reaction is Unfavourable and if RL<1 reaction is favourable

Freundlich adsorption model

The Freundlich isotherm is introduced as an empirical model, gives better fit for adsorption from liquid, can be represented as:

$$q_e = K_f C_e^{1/n}$$

Where K_f is adsorption capacity and n are adsorption intensity. K_f and n are parameters that depend on the adsorbate and adsorbent. Freundlich equilibrium constant was determined from the plot of lnq_e versus lnC_e. The n value indicates the degree of nonlinearity between solution concentration and adsorption. If $1/n > 1$ shows adsorption coefficient increase with concentration and if $1/n < 1$ shows adsorption coefficient decrees with concentration.

RESULTS AND DISCUSSION

Biosorption kinetic analysis of Chromium using algae as biosorbent

Adsorption Kinetics of chromium at 50 ppm concentration

Table 1 shows adsorption kinetics of chromium by Langmuir and Freundlich isotherm and removal efficiency by various algal biosorbents. Fresh water algal biosorbent has better adsorption capacity as compare with marine water algae for chromium. By calculating isotherms results showed that *Chara* has highest removal efficiency (96%) and maximum adsorption capacity for Cr^{+6} whereas *Scinaia furcellata* has lowest removal efficiency (87%) and adsorption capacity for Cr^{+6}.*Ulvalactuca* also showed good removal efficiency though having a low adsorption capacity for Chromium. Langmuir adsorption constant for resent study is obtained

between 0.12 to 0.25(L/mg) and R_L is obtained between 0.07 to 0.13.

Sorption study was performed to provide the maximum metal sorption capacities of various algal biomasses. Adsorption isotherm curves were performed under constant 50 ppm concentration for 48 hours. The values of K_f and $1/n$ are obtained from the linear plot. By calculating Freundlich isotherm the value of adsorption capacity (K_f) is obtained between 1.3- 41. High K_f value indicates greater adsorption capacity. The value of $1/n$ showed adsorption intensity which indicates strength of the adsorbent. Value of $1/n$ is obtained between 3.02-3.5. High value of $1/n$ showed weak adsorption bond. $1/n<1$ adsorption capacity decreases with concentration.

The applicability of each model is determined by comparing the correlation coefficients, R^2. The higher the value of R^2 the better will be the goodness of the fit [11].

Adsorption Kinetics of chromium at 100 ppm concentration

Table 2 shows adsorption kinetics for Chromium for 100ppm Cr^{+6}. By comparing calculating values of isotherm for both 50ppm and 100ppm concentration of Cr^{+6} it showed decrease in removal efficiency(RE) and adsorption constant (K_L)for both marine and freshwater algae with increased R_L value. *Chara* showed same maximum

adsorption capacity (q_m) with slightly decrees in removal efficiency for Cr^{+6}(94%). *Caule rparacemosa* showed decrees in maximum adsorption capacity while in case of *Ulvalactuca* and *Scinaia furcellata* showed increase q_m values. In case of Freundlich model, both adsorption capacity (K_f) and adsorption intensity (1/n) are observed increased with increased concentration of Cr^{+6}. High K_f 1/n values are noticed for freshwater algae, *Chara.*

Biosorption kinetic analysis of aluminium using algae as biosorbent

Adsorption Kinetics of aluminium at 50 ppm concentration

Table 3 describes adsorption kinetics of aluminium by Langmuir and Freundlich isotherm and removal efficiency by various algal biosorbents. In this case *Chara* gives highest removal efficiency (93%) in compare with marine algae with 66.7 mg/g of maximum adsorption capacity. *Ulvalactuca* showed higher adsorption capacity, 200mg/g with 91% of removal efficiency for aluminium showed good potential for the removing aluminium. Langmuir adsorption constant at 50ppm of Al^{+3} is obtained in between 0.04 to 0.13. *Scinaia furcellata* showed very low removal efficiency and adsorption capacity for aluminium adsorption. In case of Freundlich model K_f Value is reported between 2.9-14.8.

Adsorption Kinetics of aluminium at 100 ppm concentration

Table 4 shows adsorption kinetics for aluminium for 100ppm Al^{+3}.Compare to 50ppm Al^{+3}concentrations; it observed that removal efficiency is going to decrees with increased concentration of Al^{+3}. *Chara* and *Ulva lactuca* showed decrees in adsorption capacity while *Scinaia furcellata* and *Cauler paracemosa* showed increase adsorption capacity with increased concentration of aluminium. Langmuir adsorption constant is observed in range of 0.13 to 0.18.

Biosorption kinetic analysis of Iron using algae as biosorbents

Adsorption Kinetics of Iron at 50 ppm concentration

Table 5 shows adsorption kinetics of iron by Langmuir and Freundlich isotherm and removal efficiency by various algal biosorbents was observed at 50ppm Fe^{+2}. *Cauler paracemosa* showed highest removal efficiency (78%) and maximum adsorption capacity(43.5 mg/g) while *Scinaia furcellata* gives lowest removal efficiency(57%) for iron. *Ulva lactuca* indicated very low adsorption capacity for iron. Compare to other metals (Cr^{+6}, Al^{+3}), algae which was used to study show lower efficiency for Iron. R_L value is obtained between 0.21 to 0.41 and K_L is obtained in range of 0.05 to 0.13. Range of K_f is

observed between 1 to 12 and 1/n is observed in range of 3.5 to 4.1.

Adsorption Kinetics of Iron at 100 ppm concentration

Table 6 shows adsorption kinetics for iron for 100ppm $Fe^{+2.}$ All algal biomass showed reduced removal efficiency with increased level of Iron. *Cauler paracemosa* gives highest removal efficiency and maximum adsorption capacity at 100ppm Fe^{+2}. *Ulva lactuca* showed very low efficiency for Iron removal. At given concentration of iron, K_L value for all algal biomass is noticed very low. R_L was noticed between 0.24 to 0.35. Adsorption capacity and efficiency are obtained in range of 12.3 to125 and 4.8 to8.6, respectively.

From the tested algae after seven days of incubation period, the highest per centbio removal

by *Spirogyra sp.* for Cr (98.23%), Cu (89.6%), Fe (99.73%), Mn (99.6%), Se (98.16%) and Zn (81.53%) respectively. The same by *Spirulina sp.* for Cr (98.3%), Cu (81.2%), Fe (98.93%), Mn (99.73%), Se (98.83%) and Zn (79%) respectively at 5 mg/L initial metal concentration **[8]**.

Batch reactor study for chromium removal by *Oedogonium*

Column experiment was performed to check the removal efficiency of chromium with respect to time and reusability of the algal biomass. The advantages of biomass immobilization are increased volumetric reaction rate, and reduced size of bioreactors. In addition, microbial solid residence time is higher than the hydraulic residence time of the reactor, which allows avoiding biomass washout problems **[12]**.

Present study data are summarised in **Table 7**. In first cycle 100% chromium removal efficiency was observed after 5 hours of retention time. It noticed that after increasing the concentration from 100ppm to 200ppm 82% removal efficiency in 24 hours of retention time and got saturated in next cycle at 78% removal efficiency. As the number of cycles and concentration increased removal efficiency gradually decreases due to saturation of cell wall with metal ions or due to loss of algal biomass **[13]**.

It was noticed during study that *Sargassum tenerium* gave 50% removal of chromium by 6 consecutive cycle of same algal biomass, **[14]**.

Estimation of Nitrogen and phosphorous absorbance:

There are many industries which having high COD and nitrogen containing effluents which can't be release in the environment directly like food processing industry, dairy industry. So it is advisable to introduce economically feasible treatment of such effluent as it having many harmful effects on environment.

During the daytime algae can fix carbon dioxide and releases oxygen through

photosynthesis so the dissolved oxygen in the water rises. At night requires taking up oxygen and releasing carbon dioxide. These fluctuations can excess of algae growth [15]. Increase in weight of algae was observed with retention time of 48h with removal of nutrients which depicted that utilization of water pollutants was carried out by algae.

Lab scale continuous reactor was constructed to check removal efficiency of Chemical oxygen demand, nitrogen and phosphorous simultaneously. It was observed efficient reduction in concentration of COD, Nitrogen, and phosphorus when the flow rate was maintained at 0.72 m^3/ d.

It is general observation that in case of diazotroph, if readymade NH_3 or any reduced form of nitrogen were present, initially nitrogen fixing microorganisms can readily utilize available form of nitrogen despite of fixing atmospheric nitrogen.

During adaptation phase of 48 hours where there was no supply of readily available reduced form of nitrogen, *Chara* had fixed nitrogen. But when continuous flow of nutrients containing effluent was started it

had might affected nitrogen fixation capacity of *Chara.*

From the **Figure 2**, it is observed that there is reduction in phosphorous concentration from 19ppm to 0ppm was performed in 10 hours of retention time. Efficient removal of COD and nitrogen is depicted in figure 3. It is noticed that there is decrease in concentration of COD from 6000ppm to 1000ppm was observed with it 48 hours of retention time. Efficient reduction was observed during night. It is noticed that at initial NO_3-N and NH_3-N were found to increase in effluent in first 24 hours and after that there was gradually decrease in their concentration was observed to 9.4ppm and 140ppm respectively. There is gradually decrease in concentration of NO_2-N from 37ppm to 4ppm.

Chlorella spp. showed maximal growth in municipal wastewater at 30°C, pH 8 indicate that the free cells of this algae 20gm inoculum concentration without any additional nutrients could bring about more than 50% reduction in COD and BOD after96hrs. Whereas, other two strains reported BOD and COD removal efficiency in the range of 49.5 and 48.3% (*Ulva* spp.) and 43.5 and 42.2% (*Cladophora* spp.) under packed column **(Figure 3) [16]**.

Table 1: Biosorption ofCr^{+6} by various algal samples at 50ppm concentration

Name of Algae	RE* (%)	Langmuir isotherm				Freundlich isotherm		
		K_L	q_m	R_L	R^2	K_f	$1/n$	R^2
Ulva lactuca	96	0.16	20.82	0.1	0.95	1.3	3.02	0.99
Scinaia furcellata	87	0.12	25.64	0.13	0.91	2.23	3.22	0.99
Caulerpa racemosa	89	0.15	50	0.11	0.97	5.7	3.5	0.99
Chara	96.7	0.25	125	0.07	0.94	41	3.5	0.94

Table 2: Biosorption ofCr^{+6} by various algal samples at 100ppm concentration

Name of Algae	RE* (%)	Langmuir isotherm				Freundlich isotherm		
		K_L	q_m	R_L	R^2	K_f	1/n	R^2
Ulva lactuca	92	0.07	25.6	0.11	0.97	28	5.17	0.91
Scinaia furcellata	83	0.03	37.03	0.21	0.95	4.3	4.03	0.91
Caulerpa racemosa	81	0.05	6.17	0.16	0.99	3.2	3.84	0.89
Chara	94	0.12	125	0.07	0.95	112	8.34	0.95

Table 3: Biosorption ofAl^{+3} by various algal samples at 50ppm concentration

Name of Algae	RE* (%)	Langmuir isotherm				Freundlich isotherm		
		K_L	q_m	R_L	R^2	K_f	1/n	R^2
Ulva lactuca	91.4	0.4	200	0.04	0.97	14.8	4.26	0.94
Scinaia furcellata	85.26	0.12	5.3	0.9	0.99	8.7	3.8	0.99
Caulerpa racemosa	86.2	0.12	18.2	0.13	0.99	2.9	3.34	0.96
Chara	93.36	2	66.7	0.09	0.97	5.01	3.7	0.92

Table 4: Biosorption ofAl^{+3} by various algal samples at 100ppm concentration

Name of Algae	RE* (%)	Langmuir isotherm				Freundlich isotherm		
		K_L	q_m	R_L	R^2	K_f	1/n	R^2
Ulva lactuca	89.7	0.07	66.7	0.13	0.95	158	6.48	0.92
Scinaia furcelalta	8.94	0.03	31.25	0.24	0.93	26.3	5.39	0.99
Caulerpa racemosa	79.1	0.04	21.8	0.18	0.99	5.01	4.14	0.95
Chara	92.84	0.06	58.8	0.14	0.98	199.5	8.21	0.97

Table 5: Biosorption ofFe^{+2} by various algal samples at 50ppm concentration

Name of Algae	RE* (%)	Langmuir isotherm				Freundlich isotherm		
		K_L	q_m	R_L	R^2	K_f	1/n	R^2
Ulva lactuca	68	0.05	6.25	0.28	0.97	3.9	3.8	0.98
Scinaia furcellata	57	0.03	14.28	0.41	0.98	12.02	4.1	0.99
Caulerpa racemosa	78	0.13	43.47	0.13	0.96	4	3.5	0.94
Chara	62	0.07	18.51	0.21	0.97	1.02	4.1	0.98

Table 6: Biosorption ofFe^{+2} by various algal samples at 100ppm concentration

Name of Algae	RE* (%)	Langmuir isotherm				Freundlich isotherm		
		K_L	q_m	R_L	R^2	K_f	1/n	R^2
Ulva lactuca	51	0.023	7.9	0.29	0.97	31.6	5.63	0.98
Scinaia furcellata	52	0.021	10.5	0.32	0.98	125	8.6	0.97
Caulerpa racemosa	61	0.031	15.6	0.24	0.97	12.3	4.8	0.97
Chara	48	0.018	0.9	0.35	0.96	31.6	5.6	0.99

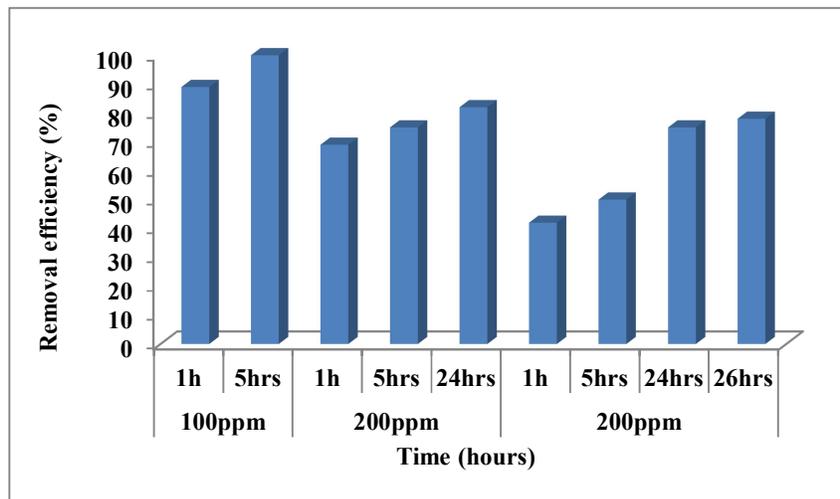**Figure 1: Column Experiment for Chromium removal**

Table 7: Batch reactor study for chromium removal by *Oedogonium*

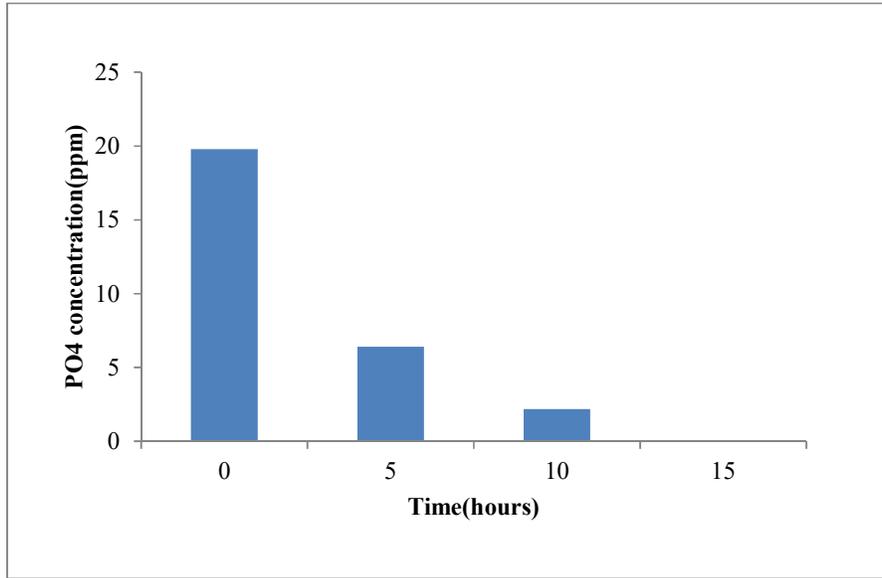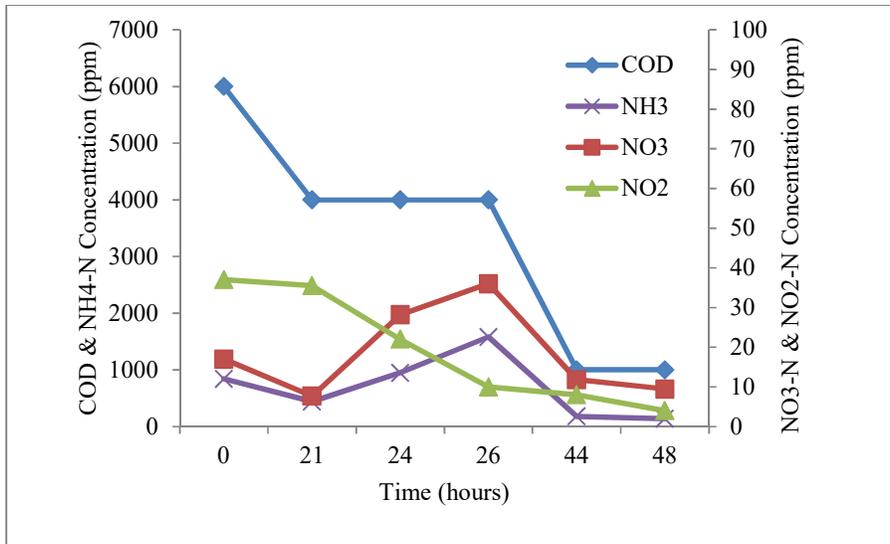| No. of cycles	Cr^{+6}(ppm)	Removal efficiency (%)	Time(hours)
1	100	100	5
2	200	82	24
3	200	78	26

Figure 2: Removal of phosphorous

Figure 3: Removal of nitrogen and COD

CONCLUSION

The main purpose of the study was to check the efficiency of different marine and fresh water algal species to remove the pollutants from the wastewater like metals (Cr, Al and Fe), nutrients (N and P) and COD and to study the kinetics of the biosorption efficiency of sorbents (algae) and adsorbate

(metal). According to the results of the present work adsorption of different metal ions at 50ppm concentration of metal was observed in the following order:Cr^{+6}:*Chara> Caulerpa racemosa > Scinaia furcellata > Ulva lactuca;*Al^{+3}:*Ulva lactuca>Chara> Caulerpa racemosa > Scinaia furcellata;* Fe^{+2}:*Caulerpa racemosa>Chara> Scinaia furcellata> Ulva lactuca .*

Adsorption of different metal ions at 100ppm concentration of metal was observed in the following order: Cr^{+6}:*Chara> Scinaia furcellata > Ulva lactuca>Caulerpa racemose;*Al^{+3}: *Ulva lactuca>Chara> Scinaia furcellata > Caulerpa racemosa;* Fe^{+2}:*Caulerpa racemosa > Scinaia furcellata> Ulva lactuca>Chara.*

In batch reactor studies used for chromium removal, approximately 78% removal efficiency was observed in *Oedogonium* and which showed consecutive removal efficiency up to three cycle. Remarkable nutrients and COD removal efficiency was observed in continuous reactor studies with increasing the biomass of *Chara* and all the pollutants were determined with in threshold value given by GPCB. It can be suggested that after proper treatment of specific wastewater by algae, it can be used for bio-sorption of metals, can be used as feedstock for biofuel production and can

applied as bio fertilizer which will reduce economic cost.

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