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REMOVAL OF HEAVY METALS FROM CONTAMINATED WATER BY ALGAE

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Abstract

A study was conducted to assess industrial wastewater for algae, heavy metals and other elements. For this purpose eighty algal samples and wastewaters were collected from industrial and natural wastewaters mostly in industrial area of Peshawar. The natural and industrial wastewater were analyzed both for algal species and concentration of heavy metals and other elements. The results showed that *Aphanocapsa, Closterium, Cosmarium, Fragilaria, Microspora, Navicula, Nitzschia, Nodularia, Oedogonium, Oscillatoria, Spirogyra, Stauroneis, Ulothrix* were the most abundant and common algal species in natural and industrial wastewater samples. Similarly ammonium, phosphorus, chromium, nickel and lead were the most abundant elements in such water samples. These results suggest that the above algal species may be tolerant to high concentration of ammonium, phosphorus, chromium, nickel and lead. The next part of study was that three types of artificial contaminated water were prepared and was inoculated with desired type of algae (mix culture of *Euglena oblonga, Oscillatoria formosa and Oscillatoria tenuis*). Algae was removed from water through centrifugation after 10 days and was dried, digested and analyzed for heavy metals, ammonium and phosphorous. The results showed that the concentration of all heavy metals and other elements were substantially reduced in the algal inoculated contaminated water. The analysis of algal biomass showed that considerable amount of metals and other elements were recovered in algae. It was observed that the removal of heavy metals, ammonium and phosphorous from contaminated water was substantially greater than its amount recovered in algal biomass. These results suggest that algae have efficiently removed heavy metals, ammonium and phosphorus from contaminated water.

Key words: Heavy Metals, Algae, Contamination and *Aphanocapsa, Closterium.*

INTRODUCTION

The development of a nation can be judged from the number and types of industries operative in a country. Industries on one hand helps in the development but at the same time also causes numerous environmental problems. Almost every factory discharges its effluents mostly containing various contaminants into natural sources of water such as sea, rivers and canals. These contaminants are dissolved in water and causes catastrophic effect on humans, animals, and the marine lives. The major industrial sectors in Pakistan are textile, metal, dying chemicals, pesticides, cement, petrochemical, energy and power, leather, sugar processing, construction, steel, engineering, pulp, paper, tanning, food processing, beverages, electronic consumer goods and mining. The typical hazards related to industry are pollution of environment including air, soil and water. Toxic and hazardous wastes in Pakistan are mainly the by-products of chemical and petro chemical dying industries. The construction industry discharges slurries of gypsum, cement, abrasives, metals, and poisonous solvents. Another pervasive group of contaminants entering food chains is the polychlorinated biphenyl (PCB) compounds, components of lubricants, plastic wrappers, and adhesives (The NEWS International, 2001). Javed and Khan (2003) evaluated the liquid effluents of various industries in Hattar Industrial Estate (HIE) for various contaminants and heavy metals. Also soil samples from different fields of HIE were analysed for heavy metals. They concluded that majority of the samples were highly polluted and these effluents if discharge to river/stream or agricultural fields may cause serious health concerns.

The biosorption of copper (II), nickel(II) and chromium(VI) from aqueous solutions on dried (*Chlorella vulgaris*, *Scenedesmus obliquus* and *Synechocystis* sp.) algae were tested under laboratory conditions as a function of pH, initial metal ion and biomass concentrations. Results showed the influence of the alga concentration on the metal uptake for all the species. Both the Freundlich and Langmuir adsorption models were suitable for describing the short-term biosorption of copper(II), nickel(II) and chromium(VI) by all the algal species. (Dönmez *et al.*, 1999). Algae have the ability to concentrate metal ions from aqueous solutions; hence a knowledge of the alga-metal interaction is important both commercially and environmentally. A mathematical model previously developed, has been successfully used to describe the uptake of cadmium by two algae, *Chlorella pyrenoidosa* and *Chlamydomonas reinhardtii* as well as by *Chlorella vulgaris*, the species used in the model's development. (Khosmanesh *et al*., 1996).

It is important that less expensive and environmentally friendly wastewater treatment methods will have to be explored and biological treatment of wastewaters is certainly one of them. For this purpose algal species have been used by many researchers.

The present study was undertaken to test selected algal species for the removal of heavy metals from wastewaters.

MATERIALS AND METHODS

Testing of Indigenous Algal Species for the Removal of Metals from Waste/contaminated water: Desired number of fresh algal samples were collected from the selected areas and were tested for the removal of metals, ammonium and phosphorus from wastewater/contaminated water. Three types of artificial contaminated water were prepared as per detail given in Table-1. Known amount (50 ml) of contaminated water was transferred to a container in quadruplicate and was inoculated with desired type of algae. The container was covered with plastic sheet to avoid evaporation. Algae was removed from water through centrifugation after 10 days and was dried, digested and analyzed for heavy metals, ammonium and phosphorous. The water sample was also analyzed for heavy metals, ammonium and phosphorus.

Measurement of Heavy Metals in Algae: Heavy Metals in algal sample was determined by the wet digestion method of Benton *et al*. (1991). In this method, algal sample was digested with 10 ml conc HNO_3 (overnight treatment) and 4 ml perchloric acid at 100 to 350^{0}C for about 1 ½ hr. After cooling, the digest was filtered through Whatman No. 42 and diluted to 25 ml, and read for heavy metals including Pb, Cd, Ni and Cr on atomic absorption spectrophotometer (Shimadzu, Model AA-6300).

Measurement of Heavy Metals in Wastewater: The concentration of heavy metal contents in the industrial wastewater and artificial wastewater samples were determined as follows: The samples were filtered through Whatman No. 42 and read for heavy metals including Pb, Cd, Ni and Cr on atomic absorption spectrophotometer (Shimadzu, Model AA-6300).

RESULTS AND DISCUSSION

Removal of Heavy Metals and Other Elements from Artificial Contaminated Water by Algae: The effect of algae on the removal of heavy metals, ammonium and phosphorus from artificial contaminated water was assessed during laboratory incubation experiment for 10 days and the results obtained are presented below:

Cadmium (Cd): The results obtained on the effect of algal inoculation on removal of Cd from contaminated water are presented in Table 2.

The results showed that cadmium concentration on average substantially reduced from 56 µg per 50 mL contaminated water without algae to 1.50 µg per 50 mL with algae during 10 days of incubation period. These results suggested that algae has substantially removed Cd from contaminated water during 10 days of incubation. The amount of Cd was also measured in algae at the end of 10 days incubation. It was observed that 16 µg per 50 mL of Cd was recovered in algal biomass indicating that algae has accumulated considerable amount of Cd in its body. It was however observed that the removal of Cd from contaminated water was substantially greater than its amount recovered in algal biomass. The obvious reason could be that we might have lost some algal biomass in the process collection, drying and weighing.

Lead (Pb): The results obtained on Pb concentration in contaminated water in the absence or presence of algal inoculation and its subsequent recovery in algal biomass are presented in Table 3. The results showed that the concentration of Pb substantially reduced from 630 µg per 50 mL of contaminated water in the absence of algae to 44 µg per 50 mL in the presence algae during 10 days of incubation. These results suggested that algae has removed substantial amount of Pb from contaminated water during 10 days of incubation.

The amount of Pb was also measured in algal biomass after 10 days. The results showed that 253 µg per 50 mL of Pb was recovered in algal biomass indicating that algae has accumulated considerable amount of Pb in its body. It was however observed that the removal of Pb from contaminated water was substantially greater than its amount recovered in algae. The possible reason could be that some of the algal biomass could have been lost in the process of collection, drying and weighing.

Nickel (Ni): Data regarding Ni concentration in contaminated water in the presence or absence of algal inoculation and its subsequent recovery in algal biomass are presented in Table 4. The results showed that the concentration of Ni was remarkably less in the algal inoculated than in un-inoculated contaminated water. It was noted that Ni concentration reduced from 226 µg per 50 mL of contaminated water in the absence of algae to 36 µg per 50 mL in the presence of algae. These results suggested that algal inoculation caused about 4 fold decrease in Ni concentration in contaminated water during 10 days of incubation. The amount of Ni recovered in algal biomass measured at the end of 10 days was 78 µg per 50 mL indicating that algae has accumulated large amount of Ni in its body. It was however observed that the removal of Ni from contaminated water was substantially greater than its amount recovered in algal biomass. As stated earlier, the possible reason could be that some algal biomass might have been lost in the process of collection, drying and weighing.

Chromium (Cr): The results obtained on the effect of algal inoculation on Cr removal from contaminated water are presenting in Table 5**.**
The results showed that the concentration of Cr decreased substantially from 187 µg per 50 mL of contaminated water in the absence of algae to 25 µg 50 mL in the presence of algae. These results suggested that algal inoculation brought about 7.5 fold decrease in the concentration of Cr in contaminated water during 10 days of incubation period. The amount of Cr recovered in algal biomass during 10 days of incubation was 40 µg per 50 mL of contaminated water indicating that algae has accumulated considerable amount of Cr in its body. It was however observed that the removal of Cr from water was substantially greater than its amount recovered in algal biomass. The obvious reason could be that some algal biomass could have been lost in the process collection, drying and weighing.

Table-1 Concentration of heavy metals in artificial contaminated water.

Type of contaminated water	Element	X (mg L^{-1})	Xx (mg L^{-1})
1	Pb	5.00	10.0
	Cd	0.01	1.0
	Ni	0.02	3.0
	Cr	0.10	2.0

x: maximum recommended concentration in irrigation H_2O; xx: concentration in artificial contaminated water.

Table 2. Effect of algal inoculation on removal of cadmium (Cd) from artificial contaminated water during 10 days of incubation.

Samples of contaminated water	Cd concentration in contaminated water (µg per 50 mL)		Removal of Cd by algae from contaminated water (µg per 50 mL)	Cd (µg) recovered in algal biomass
	without algal inoculation	with algal inoculation		
1	56	1.35	55	20
2	60	0.60	59	28
3	53	1.85	52	13
4	54	2.20	52	2
Mean	56	1.50	55	16

Table 3. Effect of algal inoculation on removal of Lead (Pb) from artificial contaminated water during 10 days of incubation.

Samples of contaminated water	Pb concentration in contaminated water (µg per 50 mL)		Removal of Pb by algae from contaminated water (µg per 50 mL)	Pb (µg) recovered in algal biomass
	without algal inoculation	with algal inoculation		
1	644	28	616	278
2	617	52	565	283
3	614	29	586	199
4	647	66	581	253
Mean	630	44	587	253

Table 4. **Effect of algal inoculation on removal of nickel (Ni) from artificial contaminated water during 10 days of incubation.**

Samples of contaminated water	Ni concentration in contaminated water (µg per 50 mL)		Removal of Ni by algae from contaminated water (µg per 50 mL)	Ni (µg) recovered in algal biomass
	without algal inoculation	with algal inoculation		
1	285	40	245	65
2	224	41	183	157
3	187	20	167	80
4	207	42	165	11
Mean	226	36	190	78

Table 5. **Effect of algal inoculation on removal of chromium (Cr) from artificial contaminated water during 10 days of incubation.**

Samples of contaminated water	Cr concentration in contaminated water (µg per 50 mL)		Removal of Cr by algae from contaminated water (µg per 50 mL)	Cr (µg) recovered in algal biomass
	without algal inoculation	with algal inoculation		
1	317	29	289	17
2	125	20	105	80
3	44	4.50	40	6
4	262	46	216	57
Mean	187	25	162	40

CONCLUSION

On the basis of our findings, it is concluded that mix culture of *Euglena oblonga, Oscillatoria formosa and Oscillatoria tenuis* are highly efficient in removal of heavy metal and other elements from contaminated water.

REFERENCES

Benton, J.Jr., B. Wolf and H.A. Mills. 1991. Plant analysis hand book. A practical sampling, preparation, analysis and interpretation guide. Micro-Macro Publishing Inc.,USA.

Donmez, G.C., Z. Aksu, A. Ozturk and T. Kutsal. 1999. A comparative study on heavy metal biosorption characteristics of some algae. Process Biochemistry. 34(9): 885-892.

Javed, H. A. and J. Khan. 2003. Study of environmental pollution associated with Hattar Industrial Estate and its effect on soil. M.Sc (Hons) thesis submitted to NWFP Agricultural University Peshawar.

Khosmanesh, A., F. Lawson and I.G. Prince. 1996. Cadmium uptake by unicellular green microalgae. The Chemical Engineering Journal and the Biochemical Engineering Journal. 62(1): 81-88.

The NEWS International. July 15. 2001. Water Quality Assessment.