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Effects of Heavy Metals on Chlorococcales Algae Oftelibandha Pondof Raipur City, Chhattisgarh, India

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Abstract: *Water is the most abundant substance in our planet. It covers more than 75% surface area of the earth.Heavy metal pollution in aquatic ecosystems is of serious concern to mankind. Planktons are located at the beginning of the food chain. Algae constitute a strategic component of aquatic environments where they grow photoautotrophically. Heavy metal pollution can remove them, resulting in complete destruction of the system. The toxic effects of heavy metals on various forms of chlococcalean algae were investigated. In the experiments conducted with different concentrations of saltsviz; 100ppm, 10ppm, 1ppm, 0.1ppm, 0.01ppm. 9 species and forms of chlorococcalean algae were presented in the Telibandha pond of Raipur city, Chhattisgarh, India.Average No. of disappearance days had been calculated for each species and forms of the algae. With the help of these observations, comparative toxicity (high to low) at different concentrations of elements with different algae have been estimated. Average number of days of survival of different species of chlorococcalean algae, with different concentrations of the elements taken for experiments presently exhibited that all the species of algae disappeared within 24 hours of exposure to 100 ppm of the salts, some of the forms of algae proved to be most sensitive and some were the most tolerant species.*

Keywords: *Heavy metal, chlococcalean algae, concentrations,Telibandhapond, disappearance days, toxicity, survival, sensitive, tolerant, Raipur city.*

I. Introduction

Heavy metal pollution in aquatic ecosystems, through intensive industrialization, urbanization and agricultural practices, is of serious concern to mankind. Planktons are located at the beginning of the food chain (Jindal and Kaur, 2000). Heavy metal pollution can remove them resulting in complete destruction of the system.

Heavy metals comprise an ill-defined group of metallic elements of density greater than 5. They have diverse physical, chemical and biological properties but generally all of them exert toxic effects on microorganisms. Algal communities have been used for monitoring the effect of industrial pollution (Cairns et al, 1978), nevertheless, algal community structure in a localized area is not caused by fortuitous circumstances or opportunistic behavior. The essential elements such as copper, zinc, cobalt have important biochemical functions in algae. The concentration of these trace elements is generally higher in the organisms than in the aquatic system and if it is otherwise, the metal content in the organism is regulated by homeostatic control mechanism (Bryan and Hummerstone 1973). At higher concentration of heavy metals the homeostatic mechanism get disrupted. Thus, during bioaccumulation of the heavy metals, the organism may be damaged (Venkataramanet al, 1992).Telibandha Pond of Raipur city area is receiving huge amounts of sewage and sullage. Polluted water of this pond is supporting several groups of algae. One of the important group, with respect to density, is chlorococcales. This group was selected for present studies.The members of this group are non motile and green, hence, could be counted and observed under microscope easily and also can be preserved with common preservatives for long time for observation. The present studies were planned to investigate the effects of different concentrations of heavy metals on chlorococcalean algae, present in the pond water.

II. Study Area and Sites

Raipur city is the capital of one of the vast growing newly emerged state Chhattisgarh. The city is located at 21^{0} 14’ North latitude and 81^{0}38’ East longitude at 260 m. above mean sea level. From the latitudinal point of view, the city lies in northern tropics, being about 160 km. South of the tropic of cancer. Raipur city is situated over a low ridge on the north east of Kharoonriver, which forms a part of Chhattisgarh basin which is characteristically flat and open. Within the Raipur city areaTelibandhapond was selected as study site. Telibandha pond is situated on the east side of the city adjoining the Great Eastern Road. This pond has an area of about 16.6 hectares.This pond is properly maintained, will not only serve as a recreational site but will also provide water for nistar purpose for the weaker section population. Telibandha pond retains water throughout the year and offers a good site to travelers.

III. Materials and Methods

Samples were collected in plastic cans. Before collecting the sample, the cans were washed thoroughly. Surface water only was collected from the ponds, for experimentation. Glass jars of four liter capacity were filled with 3 liters of pond water was taken in each of the jar. To this water, standard solution of heavy metals were added to make the concentration of the solution to 100 ppm, 10 ppm, 1 ppm, 0.1 ppm, and 0.01 ppm respectively. To experiment with the water from pond a set of six jars was prepared. One of the jars was maintained as control. Remaining five jars were prepared, one each with 100ppm, 10 ppm, 1 ppm, 0.1 ppm and 0.01 ppm of the heavy metal. The glass jars were fitted with air bubblers. Bubbling was done at the lowest speed. This was done to keep the algae floating, because neither, keeping the sample in jars resulted in settling of the algae. Before applying the heavy metal solution, 5 ml of water was taken to observe it as control.

Thereafter, 5ml water sample was taken from each of the jars, on alternate days. This alternate day collection of sample was continued till complete disappearance of algae in the sample. Density was recorded with a gap of 1 or 2 days. Change in density was followed till the days of complete disappearance of all the species. Change in density was recorded separately for all the species. Reaction, in the form of survival or death, of the chlorococcalean algae, towards presently taken concentrations (100, 10, 1, 0.1 and 0.01 ppm) of metals had always been exhibited in the form of death, sooner or later of all the chlorococcalean forms. Death has been recorded as complete disappearance of the algae from the experimental jars. Disappearance of the algae was computed concentration wise. Average No. of disappearance days had been calculated for similar concentration viz: 100 ppm, 10 ppm, 1 ppm, 0.1 ppm and 0.01 ppm separately each species and form of the algae. With the help of these observations, comparative toxicity (high to low) at different concentrations of elements with different algae have been estimated. In all the cases, pond water, in which the algae were present, had been taken as the medium for the experiment. Variation in physicochemical characters between pond water cannot be ruled out. However, considering the much drastic effects of the experimental elements, taken presently within the concentration range of 0.01 ppm to 100 ppm, the effect of differences, in physicochemical characters of pond water has been taken to be non significant.

IV. Results

Variation in density of chlorococcalean algae on successive days after the addition of different concentrations of heavy metals in the water of pond.

In Telibandha pond 8 forms of chlorococcalean algae were recorded. 1.Chlorococcuminfusionum 2.Pediastrum duplex 3.Pediastrum ovatum 4.Scenedesmus acutiformis 5.Scenedesmus armatusvar. Bicaudatus 6.Scenedesmus bijugatus 7.Scenedesmus quadricauda 8.Selenastrum minutum.

With 100 ppm concentration, all the species and forms died before first observation date after the addition of salt.

4.1 Cobalt: In the water sample taken for experimentation, Scenedesmusbijugatus, Scenedesmusarmatusvar.bicaudatus andScenedesmusquadricauda had far higher density than the other five species. Addition of cobalt had effects related to the concentration. Higher concentration of 10 ppm, killed all the chlorococcalean algae between 3 to 5 days while with the lowest concentration of cobalt (0.01 ppm) added to the water presently, some of the species particularly the algae with higher initial density survived upto 10 days.

COPPER: The initial density of algae in the water taken for experiment was almost similar to that obtained for the water sample, taken for experiments with cobalt. The species with higher density maintained their higher density also on different days after the addition of copper. The effect of copper was more drastic on the algae as none of the form was able to survive beyond 6 days with any of the presently added concentration (10 ppm to 0.01 ppm) of copper.

4.2 Lead: Scenedesmusbijugatusfollowed by Scenedesmusarmatusvar.bicaudatushad far higher density as compared to other 6 members of chlorococcalean algae in the water taken for experimentation with lead. The density decreased of all the algae on successive days after the exposure with 10 to 0.01 ppm of lead. However, the decreased density on successive day was more or less in proportion to the initial density. None of the forms was able to survive for more than 2 days with 10 ppm lead similarly none of the forms was able to survive upto 9 days after the exposure to presently taken concentration of lead.

4.3 Nickel: Initial density of chlorococcalean forms was almost similar to that observed for the sample with lead but Scenedesmusquadricaudahad also relatively higher concentration. With nickel, however, most of the forms were able to survive upto 9 days after exposure to 0.01 ppm concentration. Slope of decrease was related to the concentration of nickel applied to the water i.e. higher the concentration applied steeper was the decrease and vice versa.

4.4 Zinc: The relative initial density of algae was almost similar to that observed in the water taken for experiments with nickel. However, out of the 8 forms of chlorococcales, recorded only 2 were able to survive upto 8 days with even 0.01 ppm of zinc and incidently both were the forms having higher initial density.

Table- Disappearance days of chlorococcalean algae on successive days after the addition of different concentrations of heavy metals in the water of Telibandhapond. With 100 ppm concentration, all the species and forms died before first observation date after the addition of salts.

.No.	Species	Conc. (ppm)	No of disappearance days, after the addition of Salts				
			Co	Cu	Pb	Ni	Zn
1	Chlorococcuminfusionum	10	3	2	2	3	7
		1	5	4	6	6	7
		0.1	9	4	7	9	9
		0.01	10	6	9	9	9
2	Pediastrum duplex	10	3	2	2	2	5
		1	5	2	3	5	5
		0.1	9	3	3	7	5
		0.01	8	4	4	7	6
3	Pediastrumovatum	10	3	2	1	3	7
		1	5	2	4	7	7
		0.1	9	4	5	9	7
		0.01	9	6	7	9	8
4	Scenedesmusacutiformis	10	3	2	2	3	4
		1	5	2	3	6	4
		0.1	7	3	5	8	5
		0.01	10	4	6	9	5
5	Scenedesmus armatusvar. bicaudatus	10	3	2	2	2	8
		1	7	4	5	7	8
		0.1	11	6	5	9	8
		0.01	11	7	9	10	9
6	Scenedesmusbijugatus	10	3	2	2	2	8
		1	7	4	5	7	8
		0.1	11	6	5	9	8
		0.01	11	7	9	10	9
7	Scenedesmusquadricauda	10	3	2	1	2	8
		1	7	2	5	7	8
		0.1	11	3	5	9	8
		0.01	11	4	9	9	9
8	Selenastrumminutum	10	3	2	2	3	7
		1	4	3	5	5	7
		0.1	8	3	6	8	8
		0.01	8	4	8	9	9

V. Discussion

Ponds and algae are as closely associated as are the ponds and water. Cyclic oscillation of algal population in pond water are common phenomena but such oscillations are more prominent in the ponds with pulse stability becoming dry during long spell of drier months. Studies on the effects of pollutants, including the heavy metals, as taken presently, could be done in a defined culture solution or in a semisolid media. Effects of pollutants may be different under such conditions as compared to their effects in their natural habitat. Hence, the present experiments were performed in natural habitat of the algae, so that the effects, observed, are only due to the effects of the substances added. The procedure experimenting, without determining the concentration of substances to be experimented can raise a serious question about the background concentration of the substances being taken for adding to the natural habitat of the algae. However, long survival of the algae in the habitat indicates that the substances, if present, were at subtoxic level, while the substances added for the experiment were at the higher and toxic level. Thus, making of the effect of heavy metal, if present,in the pond water, were at much lower level.Disappearance of all the algal forms, with 100 ppm concentration of presently investigated the salts, before the first observation date, which was 48 to 72 hours after the addition of the salt, indicates that 100 ppm concentration of presently taken salt is highly toxic to all of the (chlorococcalean) algae. Decreasing the concentration of the elements in water, resulting in increasing the number of days of survival of algae indicates that the toxicity is only due to the concentration of salt and not due to any other factor. On successive days after the addition of the salt, the algae exhibiting generally proportionate decrease is because the effects ofthe different concentrations of the elements is almost similar for all the species. All metals exhibit similar inhibitory effects with increasing concentration. These effects include the depression of net growth rates, morphological changes in cells and eventually death (Sorentino, 1978). Similar results have been observed by Eichorn (1974), De-Filippis (1979), Raiet al (1981), Prasad et al (1991), that heavy metal toxicity is through poisoning and inactivation of enzyme systems, many of the morphological, physiological, biochemical and cytological processes viz: photosynthesis, respiration, protein synthesis, chlorophyll synthesis, permeability of plasma membrane, cell division etc. are severely affected at high concentration of heavy metal. However, some exceptions had been observed with respect to concentration-death effects.

RELATIVE EFFECTS OF DIFFERENT CONCENTRATIONS OF DIFFERENT ELEMENTS: Relative effects of different concentrations of different elements was found to be different on different forms of chlorococcalean algae investigated presently with respect to the effects of different concentrations of the elements.

10 ppm: At 10 ppm concentration, lead was found to exert maximum toxicity on as many as 3 of the forms, while copper was second to be most toxic to one of the form. Zinc could not exhibit maximum toxicity to any of the forms. Cobalt and nickel with maximum toxicity for 2 of the forms were intermediate in effects.

1 ppm: With 1 ppm concentration copper exhibited to be the most toxic with as many as 4 of the species far behind the zinc,lead, nickel and cobalt.

0.1 ppm: At 0.1 ppm, 4 chlerococcalean forms indicating maximum toxicity for copper. Out of the five elements experimentedpresently, lead was the only element to have maximum toxicity but only against 1 of the forms.

0.01 ppm: Maximum toxicity shown by the 4 elements at 0.01 ppm was more spectacular. Copper dominated with maximum toxicity followed by 1of the form bylead.

VI. Conclusion

Over all, at all the four concentrations (10 ppm, 1ppm, 0.1 ppm and 0.01 ppm) copper dominated the toxicity results.lead falling second in order of toxicity, exhibited maximum toxicity to a good number of forms. Cobalt on the average proved to be more toxic than nickel while between the five elements zinc never showed to be maximum toxic at any of the concentrations, experimented presently.(Cu>Pb>Co>Ni>Zn)

In total 8 species and forms of chlorococcalean algae, recorded in the water sample from the Telibandhapond, set up for experiments with different concentration of different heavy metals, some of the forms of algae proved to be most sensitive and some were the most tolerant species. These are shown in the table given below: --

Metal	Conc.	Most sensitive species	Most tolerant species
Cobalt	10ppm	*All the species disappeared within 3 days after the exposure.	* ----
	1ppm	*Selenastrumminutum	*S. quadricauda, S. armatusvarbicaudatus, S. bijugatus
	0.1ppm	*S. acutiformis	*S. quadricauda, S. armatusvarbicaudatus, S. bijugatus
	0.01ppm	*Selenastrumminutum, P. duplex	*S. quadricauda, Sarmatusvarbicaudatus,S. bijugatus
Copper	10 ppm	*All the species disappeared within 48 hours after the exposure.	*---
	1 ppm	*P. duplex ,P.ovatum, S.acutiformis,S.	* Chlorococcuminfusionum, S.

	0.1 ppm 0.01 ppm	quadricauda * P. duplex, S.acutiformis , S. quadricauda * P. duplex, S.acutiformis , S. quadricauda, Selenastrumminutum	armatusvarbicaudatus, S. bijugatus * S. armatusvarbicaudatus, S. bijugatus * S. armatusvarbicaudatus ,S. bijugatus ,Schroederiaindica *S. armatusvarbicaudatus, S. bijugatus
Lead	10 ppm 1 ppm 0.1ppm 0.01 ppm	All the species disappeared within 24 hours to 48 hours after the exposure. * P. duplex,S.acutiformis * P. duplex. * P. duplex	*--- *Chlorococcuminfusionum *Chlorococcuminfusionum *Chlorococcuminfusionum S. armatusvarbicaudatus , S. quadricauda
Nickel	10 ppm 1ppm 0.1 ppm 0.01 ppm	* P. duplex , S. armatusvarbicaudatus, S. bijugatus * P. duplex, Selenastrumminutum *P. duplex *P. duplex	* Chlorococcuminfusionum, P. ovatum, S. armatusvarbicaudatus *P. ovatum, S. armatusvarbicaudatus ,S. bijugatus , S. quadricauda *Selenastrumminutum,P. ovatum, S. armatusvarbicaudatus ,S. bijugatus , S. quadricauda * S. armatusvarbicaudatus ,S. bijugatus
Zinc	10 ppm 1 ppm 0.1 ppm 0.01 ppm	* S. acutiformis * S. acutiformis *P. duplex, S. acutiformis * S. acutiformis	* S. armatusvarbicaudatus ,S. bijugatus, S. quadricauda .* S. armatusvarbicaudatus ,S. bijugatus, S. quadricauda * Chlorococcuminfusionum *Chlorococcuminfusionum, S. armatusvarbicaudatus ,S. bijugatus, S. quadricauda, Selenastrumminutum

P = Pediastrum, S = Scenedesmus

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