RESPONSES OF CHLOROCOCCALES ALGAE TO NICKEL

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ABSTRACT

The toxic effect of zinc on various forms of chlorococcalean algae were investigated. In the experiments conducted with different concentrations of salt viz; 100ppm, 10ppm, 1ppm, 0.1ppm, 0.01ppm. 17 species and forms of chlorococcalean algae were almost uniformly presented in the six ponds of raipur city (chhattisgarh). Average no. of disappearance days had been calculated for each species and forms of the algae from the different ponds. With the help of these observations, comparative toxicity (high to low) at different concentrations of element with different algae have been estimated. Average number of days of survival of different species of chlorococcalean algae, with different concentrations of the nickel taken for experiments presently exhibited that all the species of algae disappeared within 24 hours of exposure to 100 ppm of the salt, some of the forms of algae proved to be most sensitive and some were the most tolerant species.

Key words: Nickel, chlorococcalean algae, concentrations, ponds, disappearance days, toxicity, survival, sensitive, tolerant, raipur city.

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 separation of some essential and nonessential metal ions into class $A$ (ca, mg, mn, k, sr and na), borderline (zn, pb, fe, cr, co, ni, as and va) and class $B$ (cd, cu, hg, and ag) appears to be the most useful. According to this classification scheme of nieboer and richardson (1980) all “heavy metals” belong to either the “borderline” or “$B$ group”. Among ecotoxicologists, the term heavy metals is generally used to refer to metal that have been shown to cause environmental problem. At higher concentration of heavy metals the homeostatic mechanism get disrupted. Thus, during bioaccumulation of the heavy metals, the organism may be damaged (venkataraman et al, 1992). Nickel is an inhibitor of growth of microalgae at high concentrations. Angadi and mathad (1994) reported the pigment content indicate that chlorophyll a and b were maximally inhibited at higher concentrations suggested that the metal may cause disruption of the thylakoid membranes resulting in the degradation of the light harvesting pigment. Ponds of raipur city area are receiving huge amounts of sewage and sludge. Polluted water of these ponds are supporting several groups of algae. One of the important group, with respect to density, is chlorococcales. This group was selected for present studies. In the present studies, six ponds viz: ama pond, budha pond, dabri pond, katora pond, narsaiya pond and telibandha pond located within raipur city area were selected. The present studies were planned to investigate the effects of different concentrations of nickel on chlorococcalean algae, present in the pond water.

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 nickel was 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 different ponds a set of six jars was prepared for each pond. 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 nickel. 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 nickel 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 and all the pond water selected for studies. 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 metal 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 for each of the ponds 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 from the different ponds. With the help of these observations, comparative toxicity (high to low) at different concentrations of element 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 physico-chemical characters between pond waters 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 physico-chemical characters of pond water has been taken to be non significant.

RESULTS

Variation in density of chlorococcalean algae on successive days after the addition of different concentrations of nickel in the water of different ponds.

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

AMA POND

Scenedesmus bijugatus, was the most dominant species in the water taken for experiment, while Pediastrum duplex was having the least density. Species with lesser density disappeared earlier. Least dense species Pediastrum duplex and Scenedesmus obliquus disappeared first but the species with highest density (Scenedesmus bijugatus) maintained higher density till the end of the experiment upto 10th day after the addition of nickel.

BUDHA POND

In the water sample taken for experiment with nickle, Chlorococcum infusionum and Scenedesmus quadricauda had equal density (83.46x10^3/ml) followed closely by Tetraedron minimum (81.00x10^3/ml). The species appeared to be more tolerant to nickel. Kirchneriella obesa with least density at the beginning of the experiment, was to disappear after surviving for 7 days. Lesser concentration (0.01 ppm) of the salt had least drastic effect.

DABRI POND

Scenedesmus bijugatus and Scenedesmus armatus var bicaudatus had higher and almost equal density in the water sample taken for experiments. With 10 ppm concentration none of the forms was able to survive beyond 2 days after the exposure. The decrease in density with treatment with different
concentrations of nickel was related to the concentration and number of days.

**KATORA POND**

*Scenedesmus bijugatus* and *Scenedesmus armatus* var. *bicaudatus* were the most dominant species density wise. In the water sample taken for addition of and experimentation with nickel, *Scenedesmus obliquus* at lowest density. Density of different species on different days, after the addition of nickel, was much related to their initial density. Species with lesser density maintained their lower density throughout the experimental period and were also first to disappear at different concentrations of nickel.

**NARSAIYA POND**

The water sample taken for experimentation of nickel addition had maximum density of 169.36x10^3 individuals/ml with lowest density of 17.18x10^3 individuals/ml for *Micractinium pusillum*. Decrease in density was observed for all the species at all the concentrations of nickel with the increase in number of days of treatment. The decrease in density was gradual with increasing days after the addition of nickel, steeper decrease with higher concentrations and gradual decrease at lesser concentrations.

**TELIBANDHA POND**

*Scenedesmus bijugatus* followed by *Scenedesmus armatus* var. *bicaudatus* had far higher density as compared to other 6 members of chlorococcalean algae in the water taken for experimentation with nickel. The density decreased of all the algae on successive days after the exposure with 10 to 0.01 ppm of nickel. With nickel, however, most of the forms were able to survive up to 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.

### Table 1: Average Number of Days for Disappearance of Algae with Different Concentrations of Heavy Metal Nickel.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Algal species</th>
<th>Concentration of nickel in water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>100 ppm</td>
</tr>
<tr>
<td>1</td>
<td><em>Chlorella vulgaris</em></td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td><em>Chlorococcum infusionum</em></td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td><em>Kirchneriella obesa</em></td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td><em>Micractinium pusillum</em></td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td><em>Pediastrum duplex</em></td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td><em>Pediastrum ovatum</em></td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td><em>Scenedesmus abundans</em></td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td><em>Scenedesmus acutifirmis</em></td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td><em>Scenedesmus armatus</em> var. <em>bicaudatus</em></td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td><em>Scenedesmus armatus</em> var. <em>major</em></td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td><em>Scenedesmus bijugatus</em></td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td><em>Scenedesmus obtliquus</em></td>
<td>1</td>
</tr>
</tbody>
</table>
Experiments with different concentration of nickel was carried out with 17 forms of chlorococcalean algae. 100 ppm concentration of nickel proved to be much toxic, killing all the algal form within 24 hours, 10 ppm concentration of nickel in water did not allow any of the algae to survive, on the average, for more than 3 days. *Scenedesmus obliquus* proved to be the most sensitive, unable to survive for more than 24 hours with 10 ppm concentration of nickel in water. Only 2 of the species *Kirchneriella obesa* and *Tetraedron minimum* survived on the average for 3 days.

All the forms of chlorococcalean algae kept in the jars with 1 ppm concentration of nickel exhibited prolongation of survival as compared to their survival with 10 ppm nickel. Minimum period of survival, on the average was 4 days observed with 3 of the 17 species experimented with. However, *Scenedesmus obliquus*, surviving for minimum period with 10 ppm of nickel, survived on the average for 5 days with 1 ppm of nickel. Only 2 of the forms viz: *Chlorella vulgaris* and *Tetraedron minimum* survived on the average for 7 days which was maximum number of days of survival for any of the species and forms with 1 ppm concentration of added nickel to the water. Increase in survival period observed which changing concentration of nickel form 10 ppm to 1 ppm was more than 90 % to 500 %.

Keeping the algae with 0.1 ppm of nickel resulted again in increasing the number of survival days of all the species and forms but the increase was not as significant as was observed with change in nickel concentration from 10 ppm to 1 ppm. 3 of the species viz: *Chlorella vulgaris*, *Chlorococcum infusionum* and *Tetraedron minimum* survived for 9 days which was recorded to be the maximum number of days of survival of any of the forms or species of chlorococcalean algae with 0.1 ppm concentration of nickel. *Scenedesmus obliquus*, *Scenedesmus abundans* and *Micractinium pusillum* survived on the average for only 6 days which was recorded to be the minimum number of days of survival with 0.1 ppm nickel for the presently experimented chlorococcalean algae.

![Fig: Average No. of Days of Disappearance of Different Species of Chlorococcalean Algae With Different Concentrations of Nickel.](image-url)
Exposure to 0.01 ppm concentration of nickel resulted either in no change in the number of survival days as was observed with Chlorococcum infusionum, Kirchneriella obesa and Tetradron minimum or the average number of survival days increased very slightly with remaining 14 species and forms.

**NAME OF ALGAE**

A = Chlorella vulgaris, B = Chlorococcum infusionum, C= Kirchneriella obesa, D = Micractinium pusillum, E = Pediastrum duplex, F = Pediastrum ovatum, G = Scenedesmus abundans, H = Scenedesmus acutiformis, I = Scenedesmus armatus var. bicaudatus, J = Scenedesmus armatus var. major, K = Scenedesmus bijugatus, L = Scenedesmus obliquus, M= Scenedesmus quadricauda, N= Schroederia indica O= Selenastrum minutum , P= Tetraedron minimum, Q= Tetraedron muticum.

**DISCUSSION**

Disappearance of all the algal forms, with 100 ppm concentration of presently investigated the salt, 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 of the different concentrations of the element is almost similar for all the species. The metal 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), Rai et 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. Almost similar results for different ponds indicates that the quality of different ponds is almost similar at least for response towards the heavy metal (nickel) taken presently for experimentation. Nickel exhibiting a maximum survival of 9.5 days with 0.01 ppm concentration is thus intermediate in effects between copper and lead. Angadi and Mathad (1994) reported 50% survival of Scenedesmus quadricauda at the concentration at the concentration of 2.00 ppm and maximum inhibition of chlorophyll, total RNA, DNA and Protein content was noticed at 4.00 ppm of nickel. Work on the inhibition of growth at different concentrations of nickel was done by Stokes et al (1973a), Henriksson and DaSilva (1978), Stratton and Corke (1979), Rai and Raizada (1986) and Angadi (1996). Lesser variation in the number of days of survival with 10, 1, 0.1 and 0.01 ppm indicates that variation of the concentration of the elements within this range does not affect much the toxicity of the algae.

**CONCLUSION**

In total 17 species and forms of chlorococcalean algae, recorded in the water sample from the different ponds, set up for experiments with different concentration of nickel, 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.
<table>
<thead>
<tr>
<th>Metal</th>
<th>Conc.</th>
<th>Most sensitive species</th>
<th>Most tolerant species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nickel</td>
<td>10 ppm</td>
<td><em>S. oblique</em></td>
<td><em>K. obesa, T. minimum</em></td>
</tr>
<tr>
<td></td>
<td>1 ppm</td>
<td><em>S. abundans, M. pusillum, T. muticum</em></td>
<td><em>Chlorella vulgaris, T. minimum</em></td>
</tr>
<tr>
<td></td>
<td>ppm</td>
<td><em>S. abundans, S. obliquus, M. pusillum</em></td>
<td><em>Chlorella vulgaris, Chlorococcum infusionum, T. minimum</em></td>
</tr>
<tr>
<td></td>
<td>0.01 ppm</td>
<td><em>P. duplex</em></td>
<td><em>Chlorella vulgaris</em></td>
</tr>
</tbody>
</table>

K = Kirchneriella, M = Micractinium, P = Pediastrum, S = Scenedesmus, T = Tetraedron.

REFERENCES


