Effects Of Metals On The Natural Freshwater Plankton Assemblage Reared In The Laboratory

Shaikh Parveen Rajjak,Bhosle Arjun Bapurao

Research Student
Assistant Professor
School of Earth Sciences, Swami Ramanand Teerth Marathwada University,
Vishnupuri, Nanded (MAHARASHTRA) India

Abstract: The effect of heavy metals on plankton was examined. The growth response of plankton assemblage to different concentrations of metals like iron, chromium, cadmium and zinc were evaluated by means of a static laboratory bioassay. It was also demonstrated that the plankton shows a stimulatory effect at low concentration of zinc and chromium. An increase in metal concentration caused a significant reduction in the growth of plankton cells.

Keyword: Chromium, Effects, Growth response, Heavy metals, Plankton.

INTRODUCTION

The name plankton is derived from the Greek – "planktos", meaning "errant", and by extension "wanderer" or "drifter". Plankton (singular plankter) are any drifting organisms (animals, plants, archaea, or bacteria) that inhabit the pelagic zone of oceans, seas, or fresh water bodies.The collective term for the small or microscopic plants (phytoplankton) and animals (zooplankton) that drift freely in the surface waters of lakes,seas and oceans.

The knowledge of the aqueous chemistry of metal ions and their coordination compounds is very important when assessing the effects of metal ions on biological activity. Toxicity of heavy metals to microbial activity is mainly due to soluble metal ions (Sujiarittanonta and Sherrerd, 1981).

The good quality of water having paramount importance not only to the well being of man but also other plants and animals in aquatic ecosystems of which plankton are inclusive (WHO, 1996).

The most popular heavy metals include cadmium, chromium, mercury, lead, cobalt, copper, nickel and zinc. Results of several studies have shown that physical and chemical condition of aquatic ecosystems determine the occurrence, diversity and density of both flora and fauna in any given habitat, which may change with season of the year (Ayodele and Adeniyi, 2006).

Heavy metals (Cu, Zn, Mn, Pb, Fe, Cd, Cr, Hg, Ni, etc.) are a serious threat to the aquatic environment because of their toxicity, long persistence, bioaccumulation and magnification in the food chain (Whitton, 1970).

In aqueous systems, chromium exists primarily in two oxidation states, hexavalent chromium Cr (VI) and trivalent chromium Cr (III). Change in the oxidation states of chromium has a profound effect on the toxicity and bioavailability (Imai and Gloyna, 1990). Hexavalent chromium is being used extensively in variety of commercial processes and unregulated disposal of the chromium containing effluent in both developing and developed countries (Szulczewski et .al., 1997). Although chromium is an essential trace metal ion for living organisms, its elevated level is considered as mutagenic and carcinogenic (Cheung and Gu, 2003).They constitute a lot of Cr (VI) compounds which are quite soluble and thus mobile in the environment (Nieboer and Jusys, 1988). Many laboratory studies dealt with toxic effects of chromium in higher plants and algae (Bishnoy et al., 1993; Rachlin and Grosso, 1993). Chromium (VI) is the most toxic and mutagenic metal ion in biological systems. Although the toxic effects of chromium on microorganisms and invertebrates have been a topic for researchers over the past few decades (Stasinakis et. al., 2002; Hadjispyrou et al., 2001; Yap et al., 2004).

In natural waters, iron exists in either the reduced ferrous or the oxidized ferric states (Ussher et al, 2004).Iron is primarily required by phytoplankton for many of its metabolic reactions and hence is one of the most important trace metals. It is involved in intracellular respiration and oxygenic and non-oxygenic photosynthesis (Falkowski and Raven, 1997).

The concentration of zinc in natural water is generally low. The carbonates, oxides and sulphides of zinc are sparingly soluble in water while the highly soluble chlorides and sulphides tend to form zinc hydroxide and zinc carbonate. It is toxic to plants at higher level. Also it causes cramps, disagreeable taste to water, Zinc fever (chills), nausea, oedema of lungs and renal damage to the human beings (Krishnamurthy and Vishwanathan, 1991).Acute toxicity of zinc to freshwater invertebrates is relatively low than other toxic metals like Hg, Cd, Cu, Ni and As. Although some species are sensitive to zinc namely Daphnia hyaline and Cyclops abyssorum shows 48 hours LC50's at 0.055

mg/L and 0.55 mg/L at same environmental conditions respectively (Baudouin and Scoppa, 1974).

The cadmium is present as Cd+2 upto pH 8 in the absence of any precipitating anions such as phosphate and sulphides in water. It is toxic to man; causes hypertension, degenerative bone disease, injury to liver, growth retardation, CNS injury, diarrhoea and kidney damage. Although exposure of algae to heavy metals often results in the loss of cellular potassium, cadmium concentration of 0.01-0.1 mg/L also reduce the ATP concentration and chlorophyll in many species and decrease oxygen production (Moore and Ramamoorthy, 1983).

MATERIAL AND METHODS

Water samples were collected from freshwater body and density of plankton in the samples were observed. Samples for plankton abundance were fixed with preservative and were enumerated using a binocular microscope. The quantitative results were expressed as organisms / ml.

The change in density over time and metal concentrations of the plankton was the variable used to describe response. For that purpose short-term exposure of plankton to heavy metals have done in the in situ. The analytical-grade chemicals were used to prepare the various concentrations of metals. The cadmium metal, zinc powder, potassium dichromate and ferrous ammonium sulphate were used for preparation of Cd, Zn, Cr and Fe solutions respectively. The concentrations of prepared metal solutions were 1,2,5,10,20 and 50 mg/L. The density of plankton was recorded after 24 and 48 hours. Two replicates were prepared for each concentration along with a blank as a control without metals (APHA, 1998).

RESULT AND DISCUSSION

Table 1: Effect of Iron metal on plankton density.

Sr. No.	Metal concentration(mg/L)	Plankton Density (Org.X 10^3/ml)	
		24 Hours	48 Hours
1	1	1554.4	1072.7
2	2	1202.2	975.55
3	5	872.2	896.11
4	10	653.33	777.22
5	20	480.55	581.66
6	50	371.11	441.11

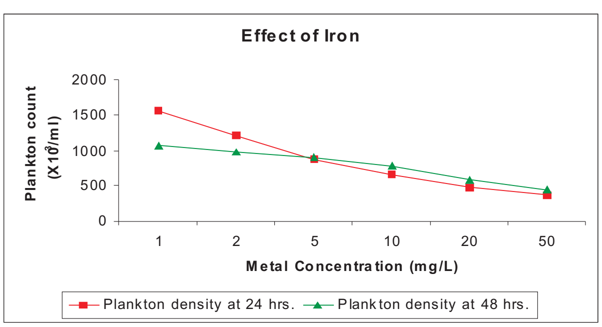

Figure 1: Effect of Iron metal on plankton density.

Table 2: Effect of zinc metal on plankton density.

Sr. No.	Metal concentration(mg/L)	Plankton Density (Org.X 10^3/ml)	
		24 Hours	48 Hours
1	1	457.7	477.77
2	2	510.5	377.77
3	5	257.2	310.55
4	10	242.2	256.11
5	20	238.33	177.22
6	50	200.97	149.44

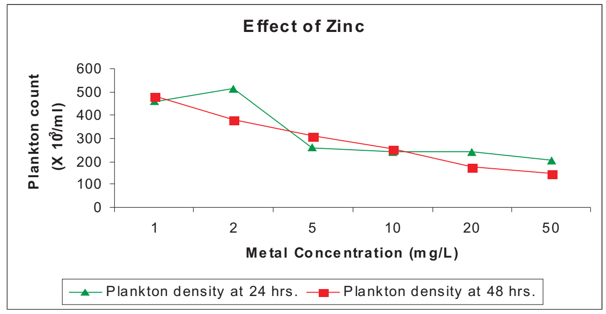

Figure 2: Effect of zinc metal on plankton density.

Table 3: Effect of chromium metal on plankton density.

Sr. No.	Metal concentration(mg/L)	Plankton Density (Org.X 10^3/ml)	
		24 Hours	48 Hours
1	1	238.33	262.7
2	2	1057.22	638.3
3	5	658.88	623.3
4	10	446.55	422.7
5	20	431.11	415.5
6	50	348.33	341.1

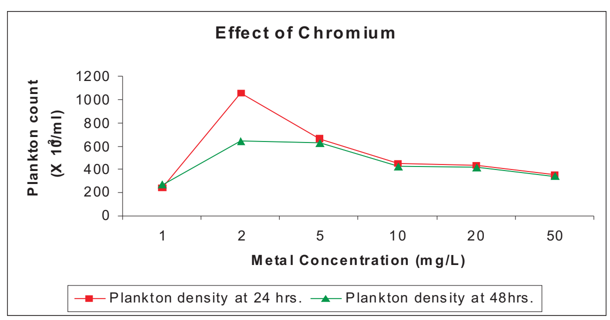

Figure 3: Effect of chromium metal on plankton density.

Table 4: Effect of cadmium metal on plankton density.

Sr. No.	Metal concentration(mg/L)	Plankton Density ((Org.X 10^3/ml)	
		24 Hours	48 Hours
1	1	658.88	493.88
2	2	465.66	402.22
3	5	463.08	400.00
4	10	392.22	357.22
5	20	388.33	337.77
6	50	355.55	284.44

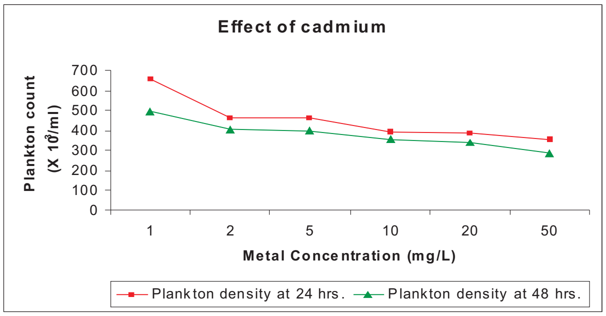

Figure 4: Effect of cadmium metal on plankton density.

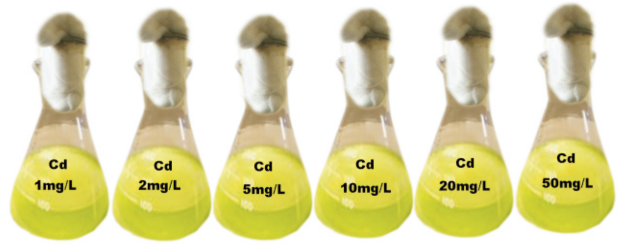

Plate 4: Laboratory setup for Cadmium metal exposure to plankton

Plate 1: Preparation of experimental setup for Iron metal and plankton

Plate 5: Laboratory setup for Fluoride exposure to plankton

Plate 2: Laboratory setup for Zinc metal exposure to plankton

Plate 3: Laboratory setup for Chromium metal exposure to plankton

The results of variations in metal concentrations (mg/L) and total plankton density (Org/ml) are presented in Tables and Figures.

An increase in iron concentration caused a significant decrease in the cell density of plankton. At 48 hours plankton density gets increased. The plankton density declined from low to high iron metal concentration.

The number of plankton cells decreases as the metal concentration increases but at 1-2 mg/L concentration of zinc metal solutions plankton number increases. At low concentration zinc is useful for the growth of algae. Plankton cell counts showed a decrease in abundance about 74.3 % from lower to higher metal concentration at the end of the experiment.

The plankton number decreases as the metal concentration increases but at 1-2 mg/L concentration of chromium metal solutions plankton number increases. In summary, chromium is toxic to plankton, although according to some report low; chromium concentration can stimulate the growth of plants and algae. As the exposure time increases plankton number decreases.

The effect of cadmium to plankton was investigated using increasing concentrations of cadmium (1- 50 mg/L). An increase in cadmium concentration caused a significant decrease in the cell number of plankton. About 80 % plankton reduction occurs from lower to higher metal concentration at the end of the period.

The same concentrations of metals were toxic to plankton except for chromium and zinc at low concentrations. The plankton reduction mostly occurs in cadmium followed by zinc, iron and chromium from selected metals. Toxicity of chromium to plankton is low as compared to other metals.

Mortuza et. al. (2005) reported that the cell numbers decreased tremendously in the presence of 100 µM potassium dichromate within 24 h, showed acute toxicity to the cell. Zsolt and Arpad (2002) investigated the effects of chromium (VI) to Chlorella pyrenoidosa using increasing concentrations of chromium (0- 50 ppm). An increase in chromium concentration caused a significant decrease in the cell density and cell number of Chlorella pyrenoidosa. Also they studied the effect of iron concentration on Chlorella pyrenoidosa in that they conclude that at control cell number were 148, 114 at 1 mg/L and 78 at 5 mg/L concentration of iron.

Carolina et. al. (1995) demonstrated that the algal responses to Zn+2 were selectively concentration dependent at 2.5 and 10 mg/L a stimulatory effect was observed in the diatoms; at 25 mg/L, diatom toxicity occurred. In contrast, Chlorophyceae and Bacillariophyceae growth was stimulated at the maximal Zn level. Chlorella sp. is one of the most tolerant algae to metals while diatoms were very sensitive to the metals. In general, the diversity, richness and equitability of the community were adversely affected by Zn in a concentration dependent fashion. Mills (1976) reported that zinc at concentrations 0.0075 and 0.075 mg/L caused 20 and 100% reductions in cell numbers of Euglena gracilis within 48 hours respectively. This sensitivity probably due to absence of thick cell walls which permit the movement of zinc into the cell interior.

Macfie et. al. (1994) observed the declined cell density of Chlamydomonas reinhardtii with increasing concentration of cadmium metal 0-20 ppm. The cell density decreased from 106 to below 105 cells/ml.

Christabelle et. al. (2011) observed that phytoplankton cell numbers increased significantly with time in ilmenite amended flasks and maximum abundance was recorded at 28 day in both the treatments of added iron and added ilm. Initial cell number was 8 X 10 3 cells /L. Similarly in 'added Fe' treatment, peak abundance was attained on the seventh day and the abundance was 70.9 X 104 cells /L. The number of plankton increased for first three days but after that increased days plankton number decreased.

CONCLUSION

We demonstrated the influence of metals on the abundance of plankton. The reduced rates of plankton number were recorded from treatments with relatively greater concentrations of metals. It means that high metal content shows negative effect on aquatic biota. Also, as the time period increases plankton density decreases. The order of toxicity of selected metals to the plankton is, Cd>Zn>Fe>Cr.

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