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Original Research Paper

Heavy Metal Accumulation in Plankton of Halali Reservoir- A Biomonitoring Approach

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ABSTRACT

Halali reservoir is a freshwater resource of Madhya Pradesh. It receives untreated domestic sewage and municipal wastes and also agricultural runoff from the surrounding areas. Different heavy metals (Fe, Mn, Ni and Pb) were measured in Halali reservoir during 2007-08 by using ICP-OES. Heavy metal contents were found significantly different among the sites and varied in the seasons. All the metals were higher at station H1 and confirm this site as a major source of pollution in the reservoir. Heavy metal content in plankton followed the order: Fe>Mn>Pb>Ni in all the seasons. Pb showed the highest bioaccumulation with high BAF values, although it was within the permitted level in reservoir's water. In this communication the concentration of metals in plankton can affect the associated fauna of the water body, and finally the impact can be seen on human health by the process of biomagnification.

INTRODUCTION

The pollution of aquatic ecosystem is recognized as the widespread environmental problem. Harmful industrial wastes, chemicals and sewage disposal are the major cause of this serious concern. A variety of chemicals used in drugs, cosmetics, paints, cleansing agents and many other consumer products may unfortunately end up in aquatic environment. Heavy metals are referred to as "conservative pollutants" because they are either not broken at all, or they are broken down over such a period of time that they essentially become permanent addition to the aquatic environment (Som et al. 2007). The heavy metals accumulate and magnify along the food chains due to their high chemical stability character. Thus, changes in the concentration of these metals in aquatic environment may alter the physiological and metabolic activities of the aquatic organisms and hence received added impetus due to increased awareness of danger of pollution. The contamination of heavy metals in water, sediment and fishes has well been recognized and documented. The only exception is plankton which has a great ecological importance in an aquatic environment and yet not been studied in detail. Amongst them phytoplankton is the basis of food chain within a system and also a source of food for zooplankton. They can accumulate metals relatively fast from water, even at low concentration (Morris 1971) and may act as bioindicators (Forstner & Wittmann 1981). Zooplankton is also an important component which is the major source of food for higher organisms, i.e. fishes and plays vital role in energy transfer for higher trophic level (Shastree et al. 1991). Hence, it may be a useful bioindicator of heavy metal pollution.

Halali reservoir is a magnificent water body of Central India. It is one of the most fish productive reservoirs of Madhya Pradesh. The water of the reservoir is being used for drinking, irrigation and aquaculture practices. In last few years, the reservoir has been fed with domestic sewage and municipal wastes. It also receives some small-scale industrial effluents and agricultural runoff from the catchment area. In view of this, the study has been carried out to evaluate the heavy metal accumulation in the plankton of Halali reservoir.

MATERIALS AND METHODS

The plankton samples were collected seasonally during 2007-08. Five sampling stations were fixed in Halali reservoir based on their utility. The location of these stations is shown in Fig. 1. These points were marked in the reservoir with the help of the Global Positioning System (Garmin 76 CSx) so as to make repeated samplings from the same point in different seasons.

For determination of heavy metals, five samples from each site were collected each time during each season namely rainy, winter and summer. Samples were digested with HNO_3 and diluted up to appropriate amount with double distilled water (Ubaidullah 2003). They were analysed for the determination of Fe, Mn, Ni and Pb content with the help of ICP-OES (Model-Perkin Elmer Optima 21000 DV). All the

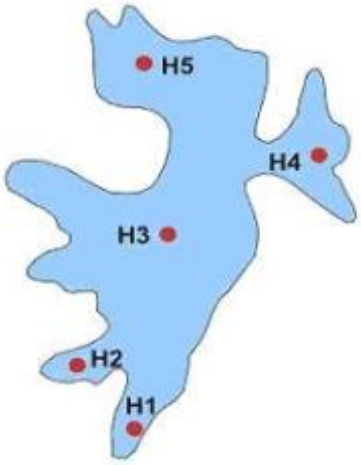

Fig. 1: Map showing the sampling stations in Halali reservoir.

samples were processed in triplicate to avoid any error.

Statistically significant differences among the sites and seasons were also evaluated by applying Duncan Multiple Range Test (Duncan 1955) to get more reliable information about the extent of heavy metal pollution. Bioaccumulation factors in plankton were also estimated to find out the relationship of plankton with their surroundings. The computer software package SPSS-10 was used to analyse the data.

RESULTS AND DISCUSSION

The concentration of heavy metals in plankton of Halali reservoir is depicted in Fig. 2. The concentration of Fe ranged between 0.255-0.489 µg/g, Mn between 0.051-0.194 µg/g, Ni between 0.0011-0.0109 µg/g, and Pb between 0.0101-0.0329 µg/g (Table 1). The maximum concentration of Fe (0.482 ± 0.00469 µg/g) was recorded at station H1 during summer season. Mn and Ni were also the highest (0.186 ± 0.00464 µg/g and 0.0106 ± 0.00029 µg/g, respectively) at station H1 during winter season. The highest mean content of Pb (0.0327 ± 0.00025 µg/g) was recorded at station H1 during rainy season.

Heavy metal accumulation in plankton depend upon several factors, such as the productivity of the water body, the physico-chemical properties of the water, quantitative and qualitative species composition of zooplankton and phytoplankton and capability of metal absorbance (Marshall & Mellinger 1980, Kerrison et al. 1998). The accumulation of different heavy metals in the plankton of Halali reservoir followed the order: Fe>Mn>Pb>Ni. Fe was the highest accumulating metal and Ni was the least. In contrary, Altindag & Yigit (2005) reported the Pb as the highest accumulating metal in the plankton of Beysehir lake. Puttaiah & Kiran (2008) reported the same metal in Jannapura lake of Karnataka.

Ni was recorded in the lowest amount with the maximum 0.0106 ± 0.00029 µg/g but it was higher than that reported by Lwanga et al. (2003) for George lake of Uganda (0.0028 µg/L), although it was the lowest accumulating metal for that site.

Seasonal and site-specific variations in heavy metal concentration were also evaluated. All the metals were higher at station H1 probably due to the addition of more untreated wastes at this site and thus confirm this site as the major source of pollution in the reservoir. However, station H5 was significantly different and lower in metal concentration from rest of the sites of the reservoir. It can be associated with the less concentration in reservoir water at this site. Site-specific variation in heavy metal concentration in plankton has also been reported by Bu-Olayan et al. (2001) in coastal waters of Kuwait.

Pb was higher during rainy season probably due to the increase in concentration of metals in the reservoir during the season which entered from the catchment area, while Fe was found to be higher during summer season which may be attributed to the increasing concentration of metals in the reservoir due to the high rate of evaporation. Higher concentration of Mn and Ni during winter season might be due to high abundance of plankton during the season and high rate of accumulation. Marshall & Mellinger (1980) and Kerrison et al. (1998) also reported seasonal variation in heavy metal concentration in plankton.

Bioaccumulation of heavy metals in plankton of Halali reservoir has also been quantified by a bioaccumulation factor (BAF) which is defined as the ratio of a particular metal concentration in plankton and the reservoir water (Mackay & Fraser 2000). The BAFs for metals during different season are given in Table 2. Ni showed the lowest accumulation during rainy season (BAF = 0.943) while Pb showed the

Table 1: Range of heavy metal concentration (µg/g) in plankton of Halali reservoir during different seasons.

Seasons	Fe	Mn	Ni	Pb
Rainy	0.255-0.435	0.075-0.185	0.0011-0.0042	0.0132-0.0329
Winter	0.261-0.472	0.051-0.194	0.0025-0.0109	0.0121-0.0279
Summer	0.271-0.489	0.061-0.188	0.0031-0.0099	0.0101-0.0151

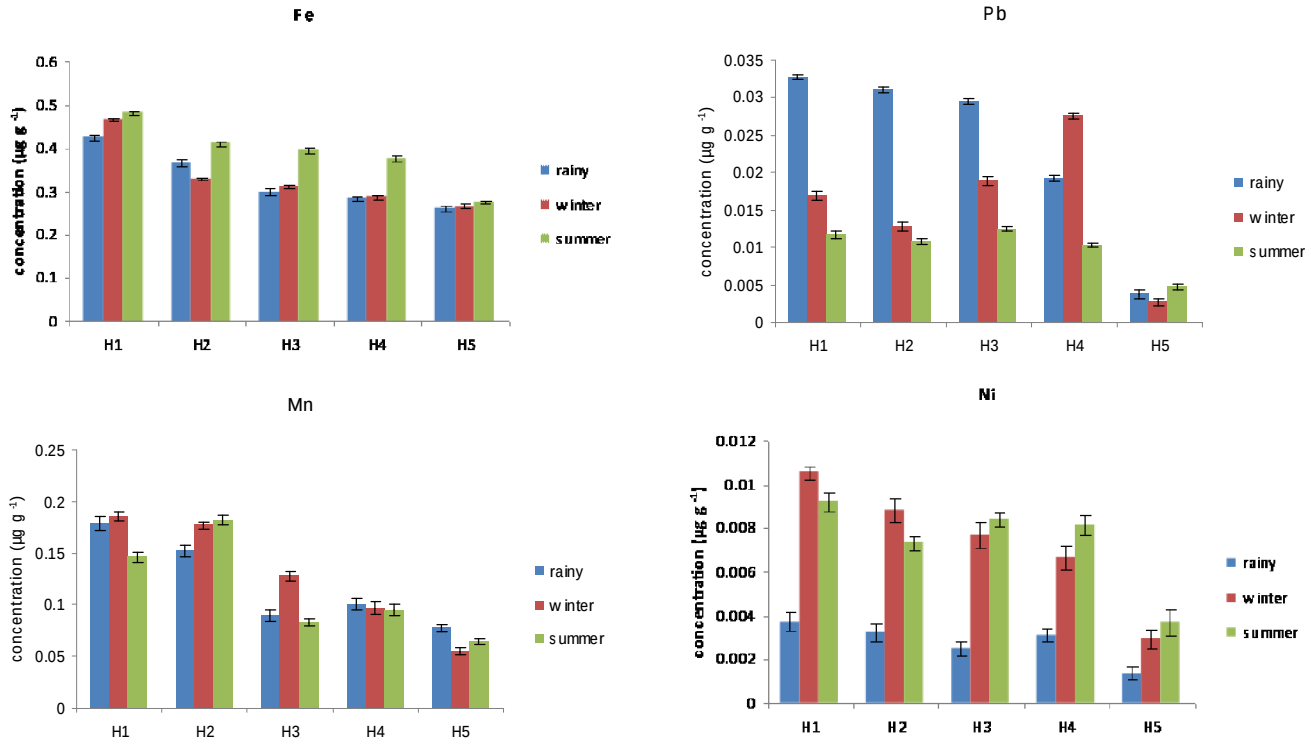

Fig. 2: Heavy metal concentration (mean ± S.D.) in plankton of Halali reservoir.

Table 2: Bioaccumulation factor in plankton of Halali reservoir.

Seasons	Fe	Mn	Ni	Pb
Rainy	2.14	1.40	0.943	16.57
Winter	1.15	1.11	3.33	13.70
Summer	1.45	1.12	2.25	4.56

highest during all the seasons, although it was not beyond limit in reservoir water. High rate of accumulation for Pb can be associated with the tendency of plankton to accumulate different heavy metals and it can become a grave concern in future.

CONCLUSION

The study showed that Halali reservoir has been contaminated with heavy metals. Most of the metals were lower in concentration. Although, the highest concentration at station H1 proved that the maximum pollution load in the reservoir comes from this site. The higher BAF values for Pb gives an alarming sign for the toxicity of biotic community with specific metal in future. Continuous disposal of wastewater and slow rate of water exchange have been deteriorating the quality of the reservoir. The study implies that currently metal pollution in Halali reservoir is at the stage of ecological concern while in future, it can become a serious concern for human health also due to consumption of contaminated fish. It is necessary to avoid the entry of wastewater in this reservoir so that this important source of water can be saved.

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