EVALUATION OF CONCENTRATION OF A FEW HEAVY METALS IN THE CATCHMENT AREA OF UPPER LAKE, BHOPAL

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ABSTRACT:

In modern economies, various types of activity, including agriculture, industry and transportation, produce a large amount of wastes and new type of pollutants. Soil, air and water have traditionally been used as sites for disposal of all these wastes. Concerns for environmental quality in nutrient management context arise mainly from pollution of ground water, eutrophication of surface water bodies, emission of green house gases and heavy metal entry into the food chain and consequently affecting human and animal health. In reference to the above, an attempt has been made to evaluate the concentration of heavy metals in five different soil samples collected from the catchment areas of Upper Lake, Bhopal. It was found that the concentration of heavy metals depended on the catchment area activities being carried out in that area.

[**Key words –** pollutants, eutrophication, food chain, heavy metals, catchment areas etc.]

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Introduction: In an aquatic ecosystem, soil is one of the most important part and ecological factor. The productivity of water body is related with soil conditions. Soil serves as a more reliable index for productivity than water qualities. The productivity of any lake depends largely on the quality of bottom soil that is "store house of nutrients." The chemical and biological changes continuously takes place resulting in releases of different nutrients in to the over lying water and their absorption by the soil mass and microbial population. The growth and abundance of different aquatic flora and fauna are greatly dependent upon the presence of essential nutrients in water body in adequate and balanced quantities. Therefore, bottom soil is described as the "chemical laboratory of lake." The ability of soil to provide various nutrients for biological production are assessed through the analysis of important soil constituents such as pH, specific conductivity, total alkalinity, calcium, magnesium, chloride, nitrate-nitrogen, phosphate-phosphorus, sulphate, sodium and potassium. Most of the dying out components of our environment is being contaminated by human activities like rapid urbanization, industrialization, population explosion, agricultural waste and anthropogenic activity in and around a lake.

Soil is an important natural resource on the earth. The soils of lake play a key role in regulating the concentration of nutrient in the lake water and aquatic flora and fauna of an aquatic ecosystem. The sedimental characteristic of an aquatic ecosystem largely depends upon their geography, particular location, siltation rate, concentration of total suspended solids and the suspended load inflow , outflow ratio etc. People on globe are under tremendous threat due to undesired changes in the physical, chemical and biological characteristics of air, water and soil. The main sources of heavy metals are fertilizers from agricultural areas, livestock manure, air pollution and emissions from vehicles. The metals accumulate in the salt marshes from polluted air *via* rain, near roads *via* splash water or by irrigation with waste water and fertilization with waste compost (**Blume & Brümmer, 1991; Blake & Goulding, 2002; Patel *et al*., 2001; Setyorini *et al*., 2002**). Over a period of time all these sources enrich heavy metals in soil. Excessive heavy metal contents changes the soil quality which affects the normal use of soil or endangering public health and living environment. Pollution of agricultural soils by heavy metals may lead to reduced yields and elevated levels of these elements in agricultural products and thus provide their entrance into food chain. Soil constituents may immobilize heavy metals, so

prevent or reduce the detrimental effects on soil organisms, crops and ground water quality (**Blume & Brümmer, 1991; Ahmad *et al.*, 2007**).

Materials and Methods: Heavy metals are natural components of the Earth's crust but rarely occur at toxic levels. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain. They cannot be degraded or destroyed.

Heavy metals can contaminate the soil as well as water. Potentially contaminated soils may occur at old landfill sites, old orchards that used insecticides containing arsenic ingredient, fields that had past applications of waste water or municipal sludge, areas in and around mining waste piles, industrial areas where chemicals have been dumped into ground etc.

The present study was undertaken to study the concentration of a few heavy metals in soil samples collected from the catchment areas of Upper Lake, Bhopal. The study was conducted for a period of two years i.e. 2011 and 2012 during the pre-monsoon and the post-monsoon seasons.

The soil samples were analyzed for the concentration of lead, zinc, cadmium and manganese in the below mentioned stations:

SS1 **Sampling station near Behata -** This station of the Upper Lake is near the Behata village. It is surrounded by agricultural Lands and also a township known by the name of Sant Hirdaram. It receives domestic sewage from the adjoining residential areas.

SS2 **Sampling station near Gandhi Medical College -** GMC is located in Fatehgarh area on Sultania Road in Bhopal, Madhya Pradesh. The college stands tall on the ground where once Fatehgarh Fort stood. It is adjacent to VIP Road, which is a major tourist attraction due to a beautiful scene of the Upper Lake. Under Bhoj Wetland project due to diversion of Nalla the entry of silt load and hospital wastes into the lake has been prevented.

SS3 **Sampling station near Van Vihar**. - This station represents the area that comes under protected forest. It is comparatively free from human interventions and other anthropogenic activities. This is an ideal spot for fish growth.

SS4 **Sampling station near Gora Bisenkhedi** - This station is situated near Gora Bisenkheri village that is the southern part of upper lake. Agricultural fields have been observed near this station

SS5 **Sampling station near Kaliasote**. - This sampling station is situated near the Kaliasote dam and also has agricultural practices going on in the nearby areas.

For heavy metals analysis, viz lead, zinc, cadmium and manganese, soil samples from the above mentioned stations were collected and transported in the laboratory for analysis. In the laboratory the samples were analyzed using Atomic Absorption Spectrophotometer as per the standard methods of **APHA**.

Results and Discussion: The use of synthetic products such as pesticides, paints, industrial waste, and land application of industrial or domestic sludge can result in heavy metal contamination of urban and agricultural soils. Exposure to heavy metals is normally chronic (exposure over a longer period of time), due to food chain transfer. The heavy metals examined in the soil samples collected during the study period and their reported values are as under:

Lead – At a high pH, lead in soil forms complex with organic matter, chemisorptions on oxides and silicate clays and precipitates as carbonate, hydroxide or phosphate. Variation in the Lead content was seen in maximum number of samples at various pH conditions. This variation can be attributed to the different types of anthropogenic activities being carried out in the catchment areas. The concentration of lead detected in the soil samples collected for a period of two years ie in 2011 and 2012 ranged between 0.03 µg/kg to 1.90 µg/kg. **Amiya Tirkey *et al.* (2012)** determined that the lead concentration in water of Upper Lake, 0.109 mg/l is above the permissible limits for drinking water by WHO (2004). This indicates a high anthropogenic activity surrounding the lake which includes idol immersion, motor boats for recreation and traffic pollution.

Zinc - Zinc occurs naturally in air, water and soil, but zinc concentrations are rising unnaturally, due to addition of zinc through human activities. Some soils are heavily contaminated with zinc, and these are to be found in areas where zinc has to be mined or refined, or where sewage sludge from industrial areas has been used as fertilizer. The concentration of zinc was found to vary from as high as 2.17 µg/kg to it being absent at a few stations. Maximum concentration was observed at sampling station Kaliasote which basically has agricultural practices in the surrounding areas. According to **G. N. Tug (2006)** the main source of Zinc concentrations examined in samples around a Salt Lake in Turkey are fertilization activities.

Cadmium –Cadmium in agricultural soil is mainly derived from the fertilizer, fungicides and sewage sludge applied in the crop field. High exposure leads to obstructive lung disease and can even cause lung cancer. Cadmium produce bone defects in humans and animals. The highest concentration during the above study was recorded at Behata station, surrounded by agricultural lands and a residential township.

It is very toxic to animals and plants and plants' exposure to Cadmium causes reductions in photosynthesis, water and nutrient uptake **(Sanità di Toppi & Gabbrielli, 1999). H. Lokeshwari *et al.* (2006)** found that the average concentration of cadmium in surface soils was six-fold higher than the natural concentration in soil around Bellandur Lake.

Manganese - Manganese is one of the more abundant elements in the earth's crusts and is widely distributed in soils, sediments, rocks and water. Manganese is a component in enzyme systems. The major anthropogenic sources of environmental manganese include municipal wastewater discharges, sewage sludge, mining and mineral processing etc. The highest concentration was observed at Kaliasote sampling station in the year 2012 during the post monsoon season. Manganese was found to be absent in the sampling station SS1 during both the years. **Praveen Jain *et al.* (1997)** observed high concentrations of Lead and manganese at all sampling stations of water of Kerwa dam, Bhopal due to dissolution of these metals from the nearby soil and sediments.

Conclusion: Higher values of heavy metals examined were generally observed at sampling stations where agricultural fields were present in the catchment and the concentration was also

found to increase in the post monsoon season. This might be probably due to extensive use of chemical fertilizers. Looking onto the above observations it is advisable to follow organic farming rather than making use of chemical fertilizers and pesticides.

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Table 1: Seasonal variations of Lead in soil samples

S.No.	Sampling Stations	2011		2012	
		Pre-monsoon	Post - monsoon	Pre-monsoon	Post - monsoon
1	SS1	0.90	1.21	1.10	1.40
2	SS2	0.06	0.04	0.03	0.07
3	SS3	1.30	1.90	1.10	1.70
4	SS4	0.08	0.10	0.07	0.12
5	SS5	0.15	0.24	0.18	0.31

Table 2: Seasonal variations of Zinc in soil samples

S.No.	Sampling Stations	2011		2012	
		Pre-monsoon	Post - monsoon	Pre-monsoon	Post - monsoon
1	SS1	0.01	0.03	0.01	0.05
2	SS2	0.02	0.01	0.03	0.07
3	SS3	1.32	1.65	1.42	1.87
4	SS4	0.00	0.01	0.01	0.04
5	SS5	1.50	1.70	1.60	2.10

Table 3: Seasonal variations of Cadmium in soil samples

S.No.	Sampling Stations	2011		2012	
		Pre-monsoon	Post - monsoon	Pre-monsoon	Post - monsoon
1	SS1	1.70	1.20	1.50	1.90
2	SS2	0.00	0.00	0.01	0.03
3	SS3	0.00	0.00	0.00	0.00
4	SS4	0.01	0.05	0.04	0.03
5	SS5	0.02	0.01	0.04	0.09

Table 4: Seasonal variations of Manganese in soil samples

S.No.	Sampling Stations	2011		2012	
		Pre-monsoon	Post - monsoon	Pre-monsoon	Post - monsoon
1	SS1	0.00	0.00	0.00	0.00
2	SS2	0.64	1.10	0.68	1.31
3	SS3	1.10	1.40	1.30	1.70
4	SS4	0.40	0.51	0.32	0.64
5	SS5	2.10	2.40	2.20	2.70

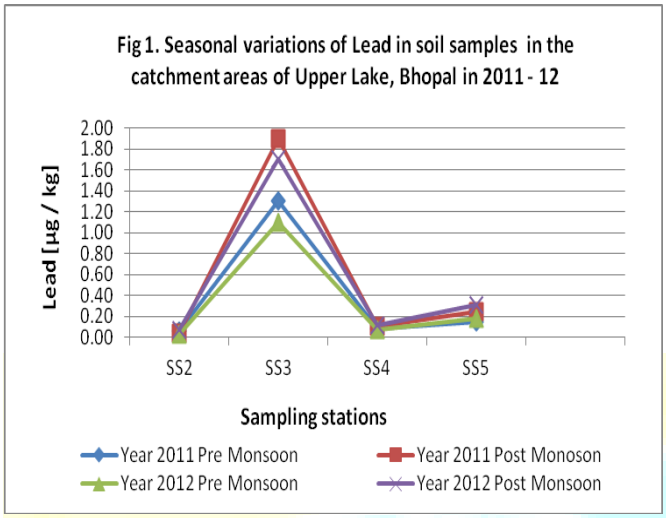
Fig 1. Seasonal variations of Lead in soil samples in the catchment areas of Upper Lake, Bhopal in 2011 - 12
Lead [µg / kg]
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
SS2
SS3
SS4
SS5
Sampling stations
Year 2011 Pre Monsoon
Year 2011 Post Monoson
Year 2012 Pre Monsoon
Year 2012 Post Monsoon

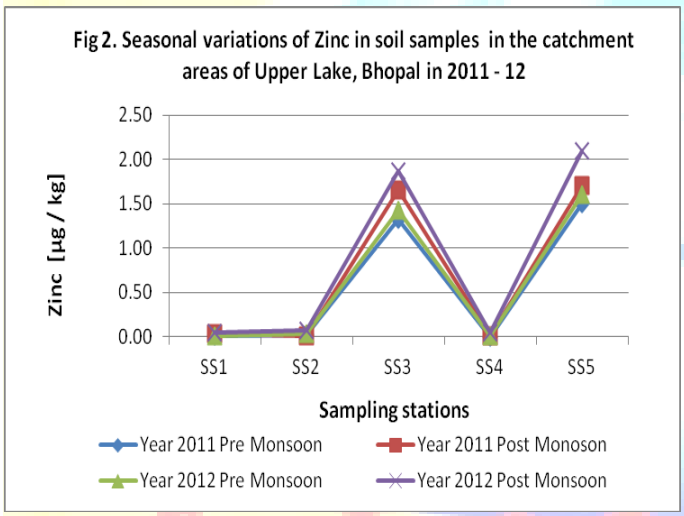
Fig 2. Seasonal variations of Zinc in soil samples in the catchment areas of Upper Lake, Bhopal in 2011 - 12
Zinc [µg / kg]
2.50
2.00
1.50
1.00
0.50
0.00
SS1
SS2
SS3
SS4
SS5
Sampling stations
Year 2011 Pre Monsoon
Year 2011 Post Monoson
Year 2012 Pre Monsoon
Year 2012 Post Monsoon

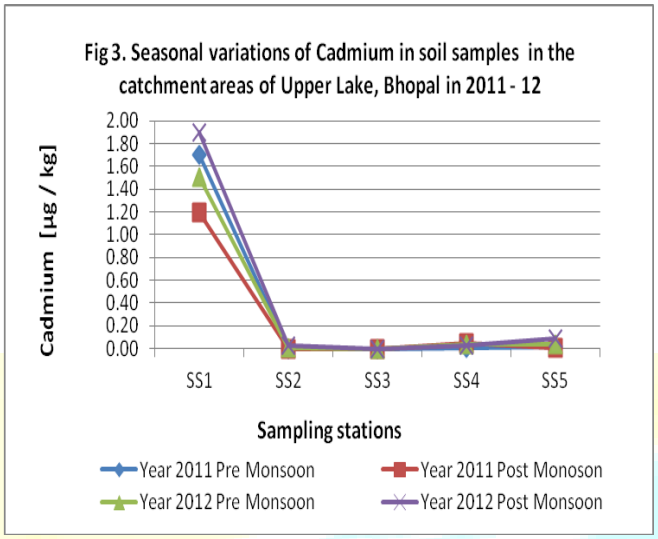
Fig 3. Seasonal variations of Cadmium in soil samples in the catchment areas of Upper Lake, Bhopal in 2011 - 12
Cadmium [µg / kg]
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
SS1
SS2
SS3
SS4
SS5
Sampling stations
Year 2011 Pre Monsoon
Year 2011 Post Monoson
Year 2012 Pre Monsoon
Year 2012 Post Monsoon

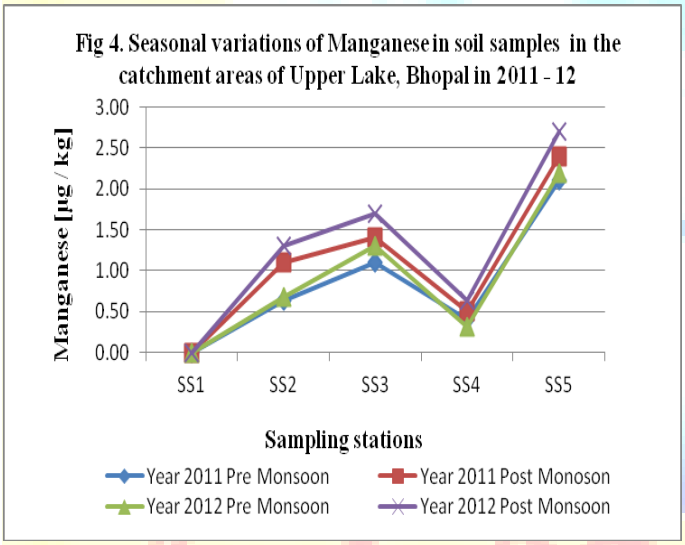
Fig 4. Seasonal variations of Manganese in soil samples in the catchment areas of Upper Lake, Bhopal in 2011 - 12
Manganese [µg / kg]
3.00
2.50
2.00
1.50
1.00
0.50
0.00
SS1
SS2
SS3
SS4
SS5
Sampling stations
Year 2011 Pre Monsoon
Year 2011 Post Monoson
Year 2012 Pre Monsoon
Year 2012 Post Monsoon