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Lead, Cadmium, Nickel, and Zinc Contamination of Ground Water around Hussain Sagar Lake, Hyderabad, India

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Metals and metallic compounds are important components of the human environment and many of these compounds are essential for human health. The mobilization of various toxic metals in our environment, however, can cause excessive exposures which may be hazardous to human health (Underwood, 1979). Metal pollution comes from both natural and anthropogenic sources (Moore and Ramamoorthy, 1984). Of the various sources of water pollution, one of the most important is however, industrial waste water directly entering aquatic systems. This has resulted in the transformation of lakes into sewage lagoons. Lake Hussain Sagar is a typical example of an industrially polluted lake, situated in the heart of Hyderabad city. The lake is heavily contaminated by various metals (Mazharuddin et al. 1985). The lake has an area of 4.83 Km^2 with mean depth of 2.5 m. Apart from minor inflows from the city, the source of water to the lake is the Kukatpally channel, which passes through the industrial zone of the city (Fig. 1). More than 400 industrial units which manufacture chemicals, drugs, paints and machine tools are located on its banks (Simhachalam, 1975). The source of the heavy metal pollution is leakage from overloaded sewers draining the industrial belt which run in to this channel. Some of the industries dump their untreated and partially treated effluent directly into the lake.

In the past 2 decades the quality of the water in the lake has deteriorated due to the impact of rapid urbanisation and industrialisation. A study of heavy metal contamination by Zafar et al. (1976) has revealed that heavy metals in different parts of the lake basin exceeded normal limits. In the recent past attempts were made to study water chemistry and heavy metal impact in the water and sediment of Hussain Sagar lake (Khan 1983, Khan and Seenayya 1985, Prahlad and Seenayya 1987). However, the impact of metal contaminated lake on the quality of ground water by seepage has been overlooked. Because the ground water is used in addition to municipal surface water, to augment water supply during summer by more than half a million city's

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population, the safety of ground water is of prime concern. Keeping this in mind, a study was initiated to determine the extent of lead, cadmium, nickel and zinc pollution in the lake and to determine the extent of ground water contamination by these metals. This study will help to delineate the area of ground water pollution and provide baseline contamination data for further investigation.

MATERIALS AND METHODS

Water samples from Hussain Sagar lake were obtained at 4 sites. Location of sites was based on morphological and bathymetric characteristics covering inflow points and central deeper region of the lake (Fig. 1). Site-1 is situated in the shallow region of the lake near the receiving point of the main inflow channel (Kukatpally chennel), depth from 1.8-3.7 m. Site-2 is on the southern side of the Mint compound, depth from 2.4-6.4 m. Site-3 is the central region of depth from 8.5-10.7 m. Site-4 is in the northern region of the lake at the formation of the feeder channel with the depth ranging from 2.7-5.8 m.

Fifty Ground water samples were collected from borewells at different sites around Hussain sagar lake, 25 samples were collected within the radius of 1 km, while the rest were collected between 1-2 Km radius as indicated on the map (Fig. 1). The water samples were brought to the laboratory in properly washed polyethylene bottles rinsed with dil. HCl. The samples were later processed following the standard procedures (APHA, 1980) and were analysed on a Perkin Elmer 2380 atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Results indicate a uniformly high degree of metal contamination in the lake. The concentration of various toxic heavy metals like lead, cadmium, nickel and zinc was elevated and are above the levels of an unpolluted system (Table 1). A study conducted by Durum et al (1971), indicates that unpolluted waters generally contain less than 1.0 μg/L of lead and cadmium. Henrickson and Wright (1978) stated that levels of 0.1-0.5 μg/L of cadmium and lead represented the background values in small Norwegian lakes. However, a study by Pande and Das (1980) revealed 20-89 μg/L of lead in lake Nainital (India). The concentration of nickel in the lake Hussain Sagar was in the range of 22-24 μg/L which is higher than those of fresh waters which usually range from 1-3 μg/L (Snodgrass, 1980). However, Keller and Pitbaldo (1986) demonstrated a relationship between elevated nickel in Sudbory area lakes and nickel emitting sources. Nickel is not a significant or widespread contaminant in most of the fresh waters, only anthropogenic inputs may increase the levels of nickel in the range of 2.5-15 μg/L (Helz, 1976) with industrial pollution being the prime contributor. The concentration of zinc in the Hussain Sagar lake was above the levels known for unpolluted water. A study carried out by Durum et al. (1971)

revealed that unpolluted waters generally contain 20 µg/L of zinc. The mean concentration of zinc in the present study was about 183.3 µg/L which although exceeding the background values but was within the normal limits of 500 ug/L recommended by ICMR (1975).

Table 1. Metal concentrations in water samples of Hussain Sagar lake

Metal	No. of samples	Range in µg/L	Arithmetic Mean	Standard deviation
Lead	10	38.40-62.45	42.16	4.1
Cadmium	10	3.80-8.00	4.60	1.4
Nickel	10	16.20-31.00	23.88	3.4
Zinc	10	48.00-271.0	181.33	6.2

Table IIa. Metal concentrations in ground water samples collected from a radius of 200-1000 m from the lake

Metal	No. of samples	Range in µg/L	Arithmetic Mean	Standard deviation
Lead	25	7.00-28.00	14.28	6.35
Cadmium	25	8.00-27.00	13.88	5.13
Nickel	25	20.00-74.00	40.08	16.58
Zinc	25	36.00-617.23	106.23	125.97

Table IIb. Metal concentrations in ground water samples collected from a radius of 1000-2000 m from the lake

Metal	No. of samples	Range in µg/L	Arithmetic Mean	Standard deviation
Lead	25	1.00-9.00	6.60	2.73
Cadmium	25	1.00-7.00	3.88	2.13
Nickel	25	0.00-20.00	11.24	5.47
Zinc	25	8.00-35.00	17.36	8.03

Results of the ground water samples collected from borewells around the Hussain Sagar lake revealed varying levels of metal contamination. In general, ground water samples collected within the radius of 1 km showed consistently higher concentrations of lead, cadmium, nickel and zinc than those samples collected beyond 1 km radius. This indicates that the source of ground water pollution is due to the contaminated lake. Lead in ground water was detected in the range of 1-25 µg/L. The concentration were appreciably higher than those for uncontaminated fresh waters which generally have values of 3 µg/L (Forstner and Witton 1979). Study conducted by UNEP/WHO (1977) revealed that, the global range of lead concentration in ground water varied from 1-60 µg/L. Cadmium concentration in the samples analysed were in the range of 1-27 µg/L (Table IIa). The mean concentration of cadmium in the water samples within 800 m radius from the lake was higher than the permissible level of 5 µg/L

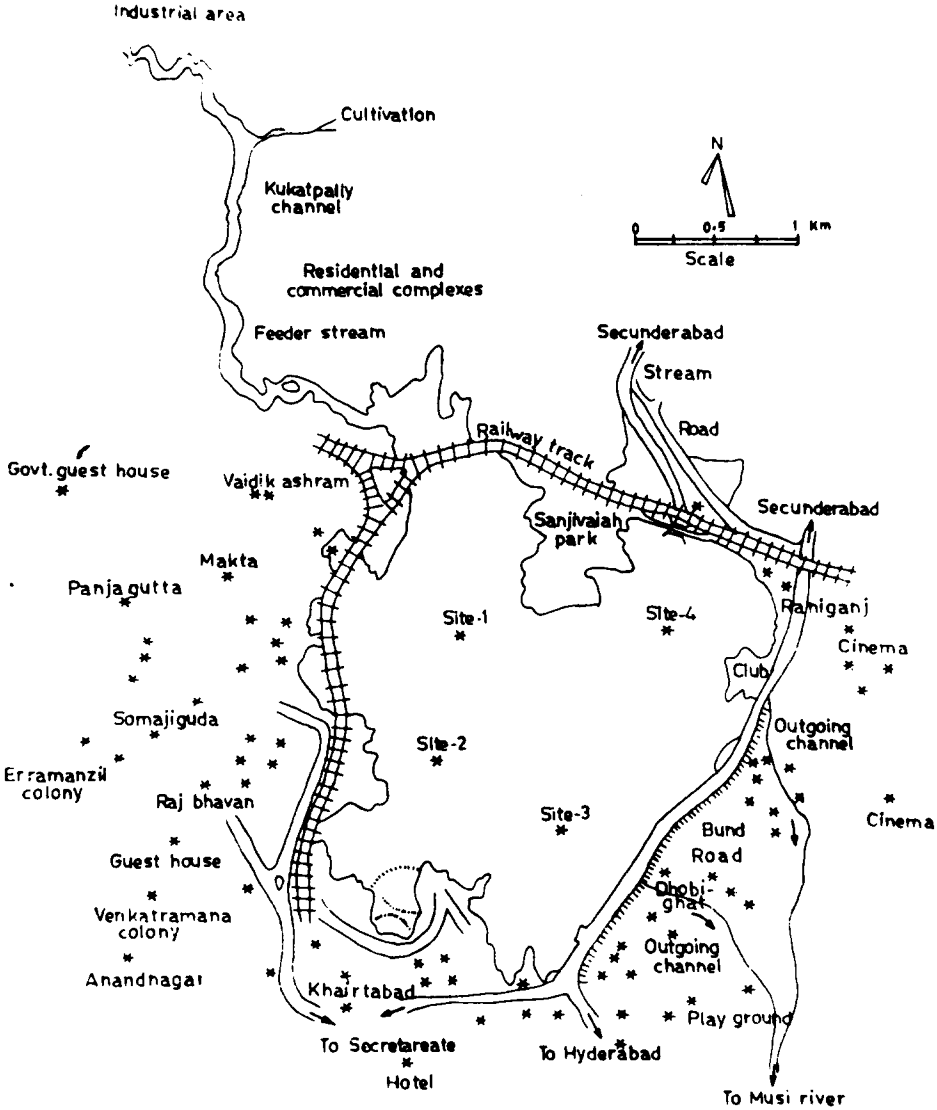

Fig.1 Husainsagar lake and its environs showing sampling sites.

recommended by WHO (1970). Cadmium concentration in the samples analysed beyond 1 km radius (Table IIb) can also be regarded as high, since the cadmium contents in ground water and drinking water are found to be very low, at 0.1-0.2 μg/L (Fishbein 1985), and is extremely low compared to the amounts of cadmium derived from the food. The concentration of nickel was in the range of 3-80 μg/L. This can be regarded as usually high considering the fact that fresh water contains, about 0.3 μg/L nickel and in the ground water it is almost negligible (Forstner and Witton 1979). Hrudey (1985) however reported that leachate from landfills contaminate ground water and may contain 1.85-8.2 μg/L. Therefore if nickel is present in surface or ground water it is likely to be in trace amounts, unless its presence is due to industrial pollution. In our present study we find that with a very few exceptions, the nickel concentration was high reaching as much as 80 µg/L. This indicates a considerable degree of seepage into the surrounding aquifiers from the lake.

The concentration of zinc was in the range of 14-617 µg/L. This can be reported as significantly high when compared to the level of zinc in fresh waters which generally range from 0.5-15 µg/L (Moore and Ramamoorthy 1984). However, with very few exceptions the ground water samples were within the permissible limit of 500 µg/L recommended by ICMR (1975). From our study we conclude that the industrial contamination of Hussain Sagar lake by various toxic metals has had a direct impact on the surrounding aquifiers. Although the degree of ground water contamination varied with the distance from the lake, the ground water samples within the radius of 800 m from the lake, showed elevated concentration of metals, especially cadmium and nickel and this may cause health risk to consumers who use ground water as a potable source during summer. This study calls for urgent remedial measures for restoration of quality of lake water such as diversion of industrial waste, thereby preventing their entry into the lake.

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