

# Assessment of the effects of municipal sewage, immersed idols and boating on the heavy metal and other elemental pollution of surface water of the eutrophic Hussainsagar Lake (Hyderabad, India)

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**Abstract** The surface water qualities of Hussainsagar, an eutrophic urban lake in the midst of twin cities of Hyderabad and Secunderabad (India) receiving large quantities of external inputs—both untreated municipal sewage containing industrial effluents, and treated sewage, a large number of annually immersed idols of God and Goddess, and intense boating activities were assessed in relation to the concentration of elements including heavy metals of the water along the necklace road of the lake. Elemental analyses of water using ICP-MS revealed 26 elements including heavy metals—As, Cd, Cr, Ni, Pb, Cu, Fe, Mn, Se, Ba, Zn, Mo, V, Co, Ag, Sr, Rb, Mg, K, Ca, Al, Si, Sb, Na, Li, and B, in the surface water of the lake. Of these, the first 15 elements were found in elevated concentrations in the water at the outfall point of the untreated

municipal sewage (site 3), which was the main dominating source of contamination of the lake water while Cu and Sb were recorded in higher concentrations at the outfall of treated effluent from Sewage Treatment Plant, and three elements (Ba, Si, and B) were in higher concentration at the sites of outfall of sewage flowing from an oxygenated pond (site 4), Ca, Zn, and Sr, at the site immersed with idols (site 1), and Pb, Ag, and Al at the center of the lake (site 5) with intense boating activities. Concentrations of most of these elements exceeded the maximum permissible limits of national (Indian Council Medical Research) standards for drinking water. The concentrations of most of the elemental contaminants showed significant positive correlations between them.

**Keywords** Toxic elements · Potential toxic elements · Major cations · Allochthonous inputs · Untreated industrial effluents · Boating

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## Introduction

Various chemical elements including nutrients and trace elements are essential for maintaining a balanced ecological and biological growth, and these elements are usually present in small amounts in the natural waters (Ward 1995). However, these are present in abundance in raw untreated municipal sewage and wastewater and

other allochthonous inputs discharged indiscriminately into the lotic and lentic systems particularly in developing countries like India. Such external inputs were found to enhance the concentrations of nutrients and potential elemental contaminants causing changes in the water quality, leading to “intoxication” of the aquatic ecosystems (Newman and Unger 2003); the plant nutrients resulting in the production of excessive biomass that when remains underutilized leads to accumulation and increase of organic matter in the system causing the appearance of algal blooms and surface floating aquatic weeds such as water hyacinth. Such a phenomenon occurring due to various anthropogenic allochthonous inputs into the water bodies is known as “Cultural Eutrophication” (Reddy 2005).

The municipal untreated and partially treated sewage and other external inputs released into urban aquatic bodies like lakes and rivers particularly in developing countries like India directly cause unfavorable changes in surface water quality. Many of the urban lakes in these countries become sinks of municipal untreated sewage and become enriched with various pollutants (Skoulidakis et al. 1998). The municipal sewage is a turbid fluid arising from domestic sewage and contains semi-decomposed and decomposed organic matter, inorganic nutrients, and different trace elements, including various heavy metals such as cadmium, chromium, nickel, lead, copper, zinc, manganese, etc. These elements being highly persistent have the potential to be toxic to living organisms including human beings (Clements and Newman 2002). Nevertheless, heavy metal pollutants can enter the aquatic environment through municipal sewage containing industrial wastewater (Forster and Wittman 1979; Soares et al. 1999). The pollution of tropical urban lakes and rivers to elemental enrichment were investigated by various earlier researchers (Reddy 2005). Information on the heavy metal contamination of urban lake water is useful in assessment of the anthropogenic allochthonous inputs (Birch et al. 1996; Jeelani and Shah 2006; Ebrahimpour and Mushrifah 2008). The input of persistent heavy metals, either in higher or lower concentrations into lake water, may be detrimental causing severe threat to the aquatic biodiversity, and endangering the pub-

lic health inflicting various serious water-borne diseases (Reddy and Kumar 2001; Clements and Newman 2002).

Most of the urban lakes in India unfortunately are discharged with untreated and partially treated municipal sewage and immersed with thousands of idols of Gods and Goddess and tazias every year, which relentlessly pollute these water bodies (Reddy and Kumar 2001; Shrivastava et al. 2003; Vyas et al. 2008), causing detrimental effects on aquatic biota (Clements and Newman 2002). Spatio-temporal variations in various elemental concentrations in surface water of the Hussainsagar, a manmade urban eutrophic lake receiving large quantities of various anthropogenic allochthonous inputs since 1960s indicated its status as hypereutrophic with recurrence of algal blooms (Reddy 2005). Monitoring and assessment of water pollution particularly heavy metal pollution of surface water of the lake is needed to provide baseline data that can be used for management and restoration of the lake. However, information documented on the heavy metal pollution of surface water in relation to the large quantities of external inputs—untreated and treated municipal sewage and others into the Lake is meager (Reddy 2005). The present study attempted to provide an assessment of the concentrations of toxic and potential toxic elemental contaminants mostly heavy metals and some cations causing unfavorable alterations in the water qualities of the Hussainsagar Lake, due to different allochthonous inputs in the form of (1) municipal untreated sewage, (2) treated sewage from an activated sludge sewage treatment plant (STP), (3) from a shallow oxygenated pond, (4) immersed idols of Lord *Ganesh* and Goddess *Durga* coated with multicolored enamel paints, and (5) due to intense ecotourism boating activities and to find out the main source of pollution. This information may be useful in initiating lake restoration measures.

## Material and methods

### Study area

Hussainsagar Lake (15° N, 81° E, and 510 m asl), a legendary manmade lake constructed in 1562 A.D.