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A PRELIMINARY SURVEY OF MERCURY IN FRESH WATER AND FISHES

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ABSTRACT

The widespread contamination by heavy metals is of major concern because of their toxicity, persistence and bio-accumulative nature. Among heavy metals, mercury is considered to be the most toxic metal. In organic form, it enters human through fish. Hence this investigation of monitoring the levels of Hg in water and fish (muscle, gill, liver and viscera) in different lakes was undertaken within Nagpur city, Maharashtra, India. The concentration of mercury in water and edible portion of fish was below the permissible limit stipulated by W.H.O. and pollution control organizations of other countries. Total mercury Hg content in Futala (0.018 mgL^{-1} to 0.042 mgL^{-1}), Ambazari (0.019 mgL^{-1} to 0.044 mgL^{-1}) and Gandhisagar (0.012 mgL^{-1} to 0.046 mgL^{-1}) lake was recorded. Generally rainy season and summer months showed heavier pollution loads, with Ambazari, Gandhisagar and Futala lake. The study while addressing water quality and interactions due to human activities in shallow lakes, also discusses problems associated with human impacts in selected lake environment.

Keywords: Water quality, Lake, Pollution, Fish, Heavy metals, health problems.

INTRODUCTION

Nagpur city is one of India's fastest growing cosmopolitan city. The city is spread in an area of about 220 Km^2. The road length of city under the Nagpur Municipal Corporation (NMC) is 1200 Km. Nagpur city is situated at an altitude of over 290 meters above sea level rising upto 350 meters towards NW, W and SW of the city. In many areas of Nagpur city tap water supply is not available and people are dependent mainly on the ground water sources. In and around Nagpur city (M.S.), there are large numbers of water bodies. Nag River which is a tributary of Kanhan takes its origin from Ambazari and flows towards east through Nagpur city. The Nag river water is completely polluted on account of draining of sewage into it. Lakes are significant resource base of Nagpur city. Some of these are used to supply water for drinking purpose like Gorewada lake and Wena tank. The water from Futala lake is used for irrigation and water from Ambazari lake is used for industrial purpose. The other water bodies in Nagpur city are, namely, Gandhisagar lake, Naik lake, Lendi lake, Sakkardara lake and Khadan lake. In Naik and Lendi lake, the ingress of sewage from nearby locality is rampant. Both of these lakes have been very much encroached by the weeds. This has been resulted into total degradation of Naik and Lendi lake. The major lakes in Nagpur city which once use to be eco-friendly and useful purposes, have lost their grandeur and have rather becomes a source of nuisance. Thus it is quite imperative to know the quality of status of these lakes water with a view to renovate them so that these serve for a useful purpose to the society. All these lakes were used for supply of water for various purposes, but, now due to heavy pollutant level, these are no more suitable for human use. India is a country of festivals, therefore the use of flowers, fruits, leaves are unavoidable. During and after festivals like Ganesh chaturthi, Durga puja, Gouri, Mahalaxmi puja, Holi, Rang Panchami etc. the leaves, fruits, flower, ash and even idols of Gods and Goddess are immersed

in the water bodies (Lakes). During year 2004, about 70 tones of biomass were collected by civic machinery. This material, if not removed, will result in depletion of oxygen due to bio-degradation of waste dumped resulting in anaerobic conditions. If the addition of bio-mass continues, the lake will be converted first into muddy ponds, then to marsh and finally to dry land. The present study was undertaken to study the quality of water of these lakes and to chalk out strategy for their renovation either for drinking purpose or for irrigation, development of fisheries, industrial purpose and also to explore the possibility of recharge of these water bodies (lakes) to the ground water. In order to save these water bodies (Lakes), which would serve us as, reservoirs of fresh water, fishes and other products for hundreds of years, the studies on the level of their pollution have been undertaken throughout the year.

Lake ecosystem are increasingly affected by various anthropogenic impacts such as excess of nutrients causing eutrophication, toxic contamination of industrial, agricultural and domestic origin as well as heat pollution reaching the lakes through their catchments area and atmosphere. Typical results of human activities proved to be elevated levels of heavy metals present in fresh water and among these microelement lead (Pb) and mercury (Hg) are most specific. Lead (Pb) and Mercury (Hg) are considered to be one of most important pollutants of aquatic ecosystems due to their environmental persistence and tendency to be concentrated in aquatic organism. In recent years, much attention has been paid to the possible danger of Hg poisoning in human as a result of contaminated fish consumption. There are several reports on Hg content of marine fish from Indian Ocean, Bay of Bengal and Arabian Sea[1-4]. However, studies on Hg concentration of freshwater and fish in India are scanty[5-6]. The present investigation deals with Hg concentration in water and fish collected from various lakes in Nagpur city, Maharashtra, India.

EXPERIMENTAL

The present investigation deals with Hg concentration in water and fish collected from the various lakes specially Futala, Gorewada, Ambazari and Gandhisagar Lake in Nagpur city (M.S).

Sampling Program

Monthly samples of water and fish were collected over a period of one year during the session December to January 2008 comprising of four seasons. Fresh fish were collected and brought to the laboratory in icebox. The following species were subject to analysis of mercury concentration in muscle and other organs.

1. Javla 2. Vogte 3. Marvels.

Digestion and Pretreatment [7]

(a) Water

Water sample of 100 ml was treated with 3 ml of concentrated. HNO_3, evaporated to dryness and the residue was dissolved in 3ml. of concentrated HNO_3 and digested until a clear solution was obtained. The resulting solution was made up to 100 ml. [8]

(b) Fish

Fish samples were cut open and different organs viz., muscle, gill, liver and viscera were separated. For each organ 5g of the sample was digested with 20ml of 10:1:2 mixture of con. HNO_3, H_2SO_4 and $HClO_4$ at 105^0C till a clear solution obtained [9]

Estimation of Hg by cold vapor technique using Mercury Analyzer

Mercury was estimated using Mercury Analyzer (ECIL 5800 MA) which works on the principle of cold vapor technique.[10] The mercury present in the pretreated sample was reduced to elemental state by using stannous salt in an acid solution. The working wavelength was 253.7 nm and the sensitivity 0.001 µg Mercury solution of concentration 100mg/l was prepared by dissolving 0.1354 gm of mercuric chloride in 2% HNO_3 and made up to 100ml using 2% HNO_3.

Calibration and estimation

The apparatus was set up and connections were checked for leakage. The required aliquot (2-4 ml) of the blank solution (respective solutions used for digesting water, sediment and fish organs) was taken in the reaction vessel. 8ml of 10% HNO_3 and 2ml of $SnCl_2$ were added and the stopper replaced immediately.

Magnetic stirrer was switched on and the contents stirred vigorously for about 5 minutes. The pump was started to allow the air to purge through the reaction vessel. Absorbance was recorded as quickly as possible. The above procedure was followed for various concentrations of standard Hg solutions and the respective absorbance recorded. A standard graph was plotted between concentration and absorbance. The above procedure was followed for the various sample solutions and the corresponding absorbance noted (after deducting the absorbance value for the respective blank solution). The Hg concentration was calculated using the standard plot.

RESULT AND DISCUSSION

A very interesting source of information about water pollution is that it affects aquatic life. Ten millions of fish are killed each year by a wide variety of different pollutants from many different sources, municipal and industrial. Mercury Hg pollution outside India is also quite alarming, even the US is also not devoid of this scar[11,12]. Hg has been recognized as a general cellular poison and effective protein precipitant. Hg vapor is almost completely absorbed through the alveolar membrane and is oxidized in blood and tissues before reacting with bimolecular. After acute administration of Hg salts to animals and man, the highest levels of inorganic Hg are found in kidneys and the second highest concentration in liver. Due to their lipid solubility, organomercurials are many times more toxic to man than the metallic form. The earliest cases of poisoning were due to occupational exposure following the introduction of methyl mercury compound as antifungal seed dressing agents. Reports of poisoning from non-occupational sources appeared with increasing frequency from 1950 onward. The primary signs and symptoms of methyl mercury poisoning results damage in the nervous system. It is characterized by ataxia (loss of coordination), diarrhea (slurred speech), parenthesis (loss of sensation at the extremities of limbs and mouth), tunnel vision (construction of visual field) and loss of hearing. Severe poisoning can cause blindness, coma and death[13]. It is found reduced activity of the enzyme with a direct exposure of Hg[14]. The studies have been carried out on the effect of methyl mercury and $HgCl_2$ on binding to the macaronis cholinergic receptor in cellular membrane isolated from the cerebrums of ringed seals[15].

Mercury is considered to be the most toxic metal. In organic form it enters the human through fish. Hence, this investigation of monitoring the levels of Hg in water and fish (muscle, gill, liver and viscera) was carried out in different lakes in Nagpur city. It may also be expected that the high concentration of metal in water can be gradually accumulated on the sediment and in due course it may get transferred to fish. Fishes being one of the main aquatic organism in food chain may often accumulate large amount of certain metals[17,18]. Directly acting metals like Fe, Pb, As, Hg and Zn are common toxic pollutants for fish[19]. In order to judge the fitness of lake water for fisheries point of view, the water quality from different lakes (Fig. 1) viz. Ambazari, Gorewada, Futala and Gandhisagar within Nagpur city (India) was tested. The data on mean mercury content in water (mg/l) and various organs of fish (mg/kg fresh weight) are given in Table 1-4 during different seasons at Gorewada, Futala, Gandhisagar and Ambazari lake for the session January to December 2008. The variation of level of occurrence of heavy metals in water was found different from each other due to variation of solubility of existing forms of metals in water as well as their availability in the immediate environment. The result of present study indicates below detectable limit of mercury content in Gorewada lake. The concentration of mercury in water varied from 0.018 mgL^{-1} to 0.042 mgL^{-1}, 0.019 mgL^{-1} to 0.044 mgL^{-1} and 0.012 mgL^{-1} to 0.046 mgL^{-1} for Futala, Ambazari and Gandhisagar lake respectively during different season for the session January to December 2008.

The result of present study indicates Hg content in water from Gorewada lake was below detectable limit in all sites during entire period of study. It is clearly evident from result that Gorewada lake water source will not cause any significant heavy metal health hazard to the water consumer; however, periodic monitoring of ground water and surface water (lakes) sources is required in order to check any further increased in heavy metal concentration due to discharge from various industrial effluent, sewage discharge or geochemical alterations. The present result indicates no specific trend is observed in mercury concentrations in different organs of fish in all four studied lakes. The Hg content in fish from all the studied lakes was below detectable limit throughout study period. Mean concentration of Hg in the edible portion of fish was well below stipulated toxic limit (0.5mg/kg) in Futala, Ambazari, Gorewada and Gandhisagar lake and hence fit for consumption.[20]

In general mercury (Hg) metal accumulation was found to be maximum at all sites in Futala and Ambazari lake. It is observed that higher concentration of heavy metals in fish organs is attributed to the types of food that fish is feeding on. Highly significant difference was noticed in case of mercury (Hg) in water samples collected from studied lakes. Mercury Hg content was below detectable limits at all sides in Gorewada lakes while in Gandhisagar lake a value in range of 0.012 to 0.046 mgL^{-} was registered. Possible cause of higher values of mercury content in studied lake water environment could be illegal discharge of slaughterhouse waste, immersion of idols, of God and Goddess in large ratio during festival seasons, surface runoff, domestic wastes and washing activities in and around these lakes. Generally, summer and rainy season's months showed heavier pollution loads. Seasonal variations show a definite trend in all studied lakes, except Gorewada lake.

CONCLUSION

The mercury Hg content in studied lakes revealed highly significant differences between seasons and locations. Generally summer and rainy season's months showed heavier pollution loads within Futala, Ambazari and Gandhisagar Lake. There is no specific trend observed in mercury (Hg) content in different tissues (gill, liver, viscera, muscle) of fish in studied area. The results shows low mercury levels in tissues of the species studied and suggest differences due to locality. The Hg content in studied lakes was below permissible limit prescribed by W.H.O. and also level stipulated by pollution control organization of other countries (0.05 mgL^{-1}). It is clearly evident from results that Gorewada, Gandhisagar, Ambazari and Futala lake water source will not cause any significant heavy metal health hazard to the water consumer, however, periodic monitoring of ground water and surface water (lakes) sources is required in order to check any further increased in heavy metal concentration due to discharge from various industrial effluent, sewage discharge or geochemical alterations. Mean concentration of Hg in edible portion of fish was well below the stipulated toxic limit (0.5 mg/kg) in all studied lakes and hence fit for consumption.

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Table-1: Mean Mercury content in water (mg/l) and various organs of fish (mg/kg fresh weight) during different seasons of the year in the FUTALA LAKE

Season	Water	Muscle	Gill	Liver	Viscera
Cold Water (Jan-Feb)	0.018	ND	ND	ND	ND
Hot Weather (Mar-May)	0.032	ND	ND	ND	ND
South West Monsoon (June-Sept)	0.042	ND	ND	ND	ND
North East Monsoon (Oct-Dec)	0.028	ND	ND	ND	ND
Mean	0.030	ND	ND	ND	ND

ND = Not detectable; BDL = below detectable limit

Table-2: Mean Mercury content in water (mg/l) and various organs of fish (mg/kg fresh weight) during different seasons of the year in the AMBAZARI LAKE

Season	Water	Muscle	Gill	Liver	Viscera
Cold Water (Jan-Feb)	0.019	BDL	BDL	BDL	BDL
Hot Weather (Mar-May)	0.022	BDL	BDL	BDL	BDL
South West Monsoon (June-Sept)	0.044	BDL	BDL	BDL	BDL
North East Monsoon (Oct-Dec)	0.031	BDL	BDL	BDL	BDL

Mean	0.029	BDL	BDL	BDL	BDL

ND = Not detectable; BDL = below detectable limit

Table-3: Mean Mercury content in water (mg/l) and various organs of fish (mg/kg fresh weight) during different seasons of the year in the GOREWADA LAKE

Season	Water	Muscle	Gill	Liver	Viscera
Cold Water (Jan-Feb)	BDL	ND	ND	ND	ND
Hot Weather (Mar-May)	BDL	ND	ND	ND	ND
South West Monsoon (June-Sept)	BDL	ND	ND	ND	ND
North East Monsoon (Oct-Dec)	BDL	ND	ND	ND	ND
Mean	BDL	ND	ND	ND	ND

ND = Not detectable; BDL = below detectable limit

Table-4: Mean Mercury content in water (mg/l) and various organs of fish (mg/kg fresh weight) during different seasons of the year in the GANDHISAGAR LAKE

Season	Water	Muscle	Gill	Liver	Viscera
Cold Water (Jan-Feb)	0.012	BDL	ND	ND	BDL
Hot Weather (Mar-May)	0.023	BDL	ND	ND	BDL
South West Monsoon (June-Sept)	0.020	BDL	ND	ND	BDL
North East Monsoon (Oct-Dec)	0.018	BDL	ND	ND	BDL
Mean	0.018	BDL	ND	ND	BDL

ND = Not detectable; BDL = below detectable limit

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Fig.-1: Map showing Gandhisagar, Ambazari, Gorewada and Futala Lake , Nagpur (MS) India.