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Fluoride Fluctuations in Lake Mansar at Surinsar-Mansar Ramsar Site in NW Himalayas

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ABSTRACT

Fluoride, an important aspect of the aquatic ecology influences not only the biological productivity but also the quality of water. Furthermore, quantum of anthropogenic influences and global volcanic activity also exerts an overwhelming effect on the concentration of fluoride in natural waters. Besides, ground water also contains higher concentrations of fluoride owing to leaching from rocks. Surinsar-Mansar ramsar site in NW Himalayas includes two lakes where Lake Mansar is the biggest one and is an only one source of fresh water to support the livelihood and biodiversity of its vicinity. Thus, the contamination in the water or imbalance in the chemistry of the lake has been always proved as the main source of epidemics in the area. Besides drinking facility, the lake provides a heavy flush of water for the agriculture practice and livestock of the area. Since Lake Mansar is a closed lacustrine system receiving water from sub-terranean springs and rains due to western disturbances in sub-continent India, hence the present study was initiated to see the fluctuation in the fluoride concentration in the lake.

Key words: Mansar Lake, Ramsar site, NW Himalayas, limnology, flouride, seasonal fluctuations

INTRODUCTION

Fluorides are the pollutants with immense significance as they have considerable potential for ecological damage (Marier, 1972). Though fluorides are essential for the proper growth and development of skeleton (WHO, 2002) yet chronic intake increases the long term metabolic requirement for calcium and magnesium (Rose and Marier, 1977). Moreover, deficiency of fluoride is known to cause dental caries, skeletal fluorosis and hip fractures (Rose and Marier, 1977; IPCS, 2002; Anonymous, 2005). Fluorides accumulate steadily in the environment as they do not break down easily.

Though, large amounts of fluoride are known to be released into the water ways yet little is known about the effects of fluoride on aquatic life. In surface waters, fluoride levels have been found to vary with local geology (Hirayama *et al.*, 1996), geothermal activity (Neuhold and Sigler, 1960) and anthropogenic sources (Harbo *et al.*, 1974; Somashekar and Ramaswamy, 1983; Van Craenenbroeck and Marivoet, 1987; Karunagaran and Subramanian, 1992; Skjelkvale, 1994a,b; Camargo, 1996a, 1996b; Zingde and Mandalia, 1998; Roy *et al.*, 2000). But phosphate fertilizers (Forster, 1969; Gordon, 1970; Amerman, 1974; McLaughlin *et al.*, 2001), weathering of minerals (IPCS, 2002; WHO, 2002; Anonymous, 2005) and solid wastes (Emma *et al.*, 1968; Fitzgerald *et al.*, 1969; Williams, 1977) also contribute to the fluoride content of the aquatic environment. In water, the transport and transformation of inorganic fluorides are influenced by pH, hardness and the presence of ion exchange materials such as clays (Rose and Marier, 1977; Anonymous, 1994).

The assessment of fluoride concentration in the context of present study is of utmost importance as Jammu and Kashmir is in high seismic zone and the Lake Mansar is under enormous anthropogenic influences derived from tourism (as the lake is a famous tourist spot), agricultural practices in the catchment area of the lake and socio-religious ceremonies.

MATERIALS AND METHODS

Lake Mansar located between 75°5'11.5" to 75°5'12.5" E and 32°40'58.25" to 32°40'59.25" N at an elevation of 666 m above mean sea level is a closed no drainage type of lacustrine system feeding about 20,000 people living in its vicinity. One of the major lake in the Surinsar-Mansar Ramsar site 1210 (Wetlands International Site No. 2IN024), the Lake Mansar is a life line for the locals of the area. The bottom sediments of the lake are of clayey sandy type with rich humus content. The bottom sediments keep on enriching every day with acute human intervention on the part of the lake and its catchment.

For the sampling of fluoride, four study stations along the bank of Lake Mansar were selected. These sampling stations were selected on the basis of vegetation and nature of pollution. While Station I is located near Mansar Bazaar, PWD Rest House and Boating Club, Station II is located near Sheshnag Mandir, Station III is located near Cremation ground, agricultural fields and Deer park and Station IV is located near JKTDC Cafeteria and pine forest. So each of these stations experience different types of anthropogenic influences that tend to enrich the lake with nutrients like influx of sewage, fertilizers, pesticides, fecal matter, decaying organic matter, detergents, soaps, third pollution etc besides the tourism that is generating enormous solid waste in the catchment of the lake.

For the estimation of fluoride, Ion Selective Electrode Method (APHA, 1975) which is suitable for the waters with 0.1>10 mg L^{-1} fluoride concentration (Greenberg *et al*., 1992) was followed.

Statistical analysis: Means were calculated of all the acquired data and the whole data was analyzed by applying the Analysis of Variances (ANOVA). Residual plots has also drawn to show the monthly variations in the fluoride concentrations.

RESULTS

During the first year of the study (Oct. 2003 to Sept.2004), average fluoride content in Lake Mansar varied from 0.0280±0.0028 mg L^{-1} (May) to 0.0462±0.0035 mg L^{-1} (September). During second year of the study (Oct. 2004 to Sept. 2005), mean fluoride concentration varied from 0.0302±0.0038 mg L^{-1} (May) to 0.0767±0.1085 mg L^{-1} (September) (Fig. 1). Careful analysis reveals that fluorides recorded a bimodal peak, one during winter and the other during monsoons. While during spring and summer, fluoride values recorded a decline (Table 1).

Winter maxima in the fluoride concentration may be due to the decomposition of aquatic plants and animals which contain both ionic and non ionic forms of fluoride (WHO, 1984) and late autumn overturning of lake due to which fluoride rich benthic layers mixes with the epilimnetic layers.

Likewise, monsoon maxima in fluoride values may be attributed to: (i) leaching of fluoride rich pesticides from agricultural fields (Bovay, 1969; Marier, 1972; McLaughlin *et al*., 2001) (ii) inflow

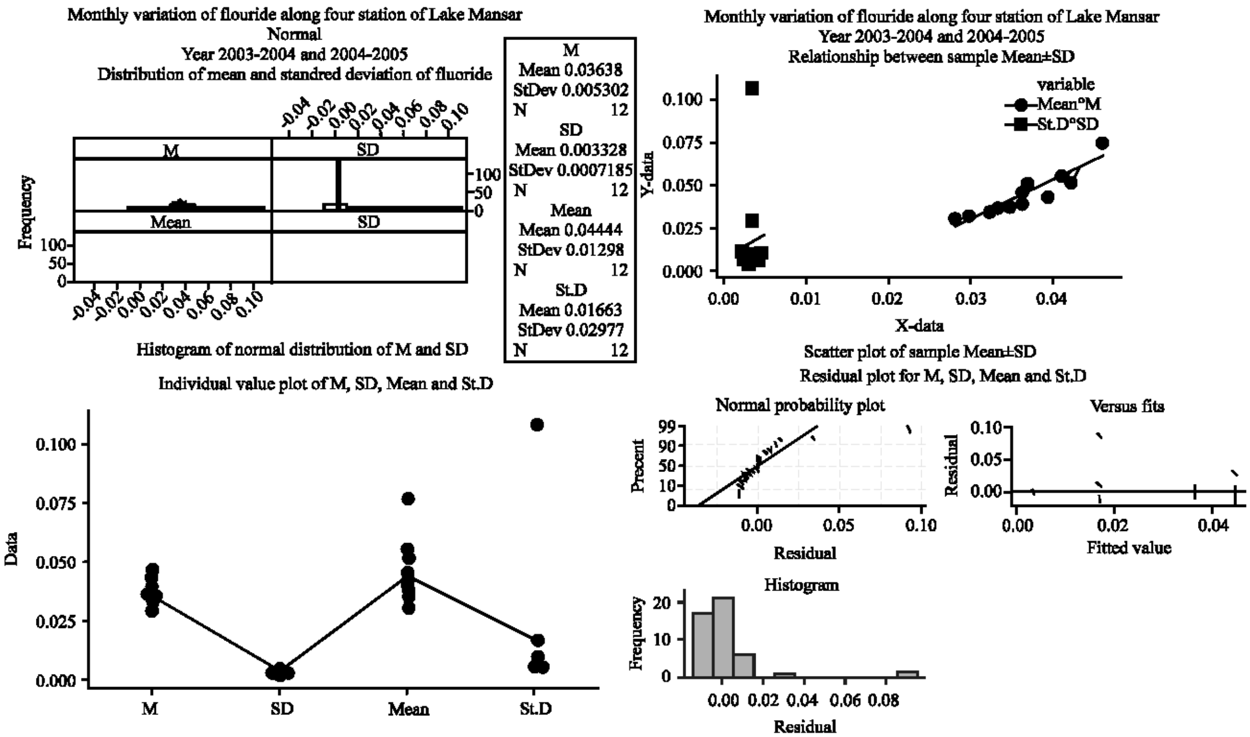

Fig. 1: Analysis of variance for mean and standard deviation of fluoride along four stations of Lake Mansar

Table 1: Monthly variation in fluoride (mg L^{-1}) along the four stations of lake mansar

Months	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Year 2003-2004												
Station I	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04
Station II	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.04	0.04
Station III	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05
Station IV	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.03	0.03	0.04	0.04
Mean	0.036	0.041	0.039	0.036	0.034	0.032	0.029	0.028	0.033	0.036	0.042	0.046
SD	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.002	0.003	0.002	0.003
Year 2004-2005												
Months	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.
Station I	0.05	0.05	0.04	0.03	0.03	0.03	0.032	0.03	0.037	0.045	0.05	0.08
Station II	0.05	0.06	0.04	0.04	0.03	0.03	0.033	0.032	0.04	0.045	0.052	0.085
Station III	0.05	0.06	0.05	0.04	0.04	0.04	0.035	0.034	0.042	0.055	0.065	0.092
Station IV	0.04	0.04	0.04	0.03	0.03	0.03	0.028	0.025	0.028	0.035	0.04	0.05
Mean	0.051	0.055	0.043	0.039	0.037	0.034	0.032	0.0302	0.036	0.045	0.051	0.076
SD	0.004	0.009	0.004	0.004	0.005	0.004	0.0294	0.0038	0.006	0.008	0.01	0.108

ANOVA table for fluoride

Source of variation	Year	df	S S	MSS	F	Significance level
Between months	2003-2004	11	0.001237	0.000112	9.72	0
Between stations	2004-2005	11	0.007415	0.000674	10.42	0
Error	2003-2004	3	0.000355	0.000118	4.01	0.013
	2004-2005	3	0.00159	0.00053	2.86	0.048
	2003-2004	33	0.000382	1.15E-05		
	2004-2005	33	0.002135	6.46E-05		

SD: Standard deviation, DF: Degree of freedom, SS: Sum of squares, MSS: Mean sum of squares

Table 2: Range of minima and maxima of fluoride (mg L^{-1}) at each of the four stations

	2003-2004		2004-2005	
Station	Minima	Maxima	Minima	Maxima
I	0.030	0.045	0.030	0.080
II	0.028	0.048	0.032	0.085
III	0.030	0.050	0.034	0.092
IV	0.024	0.042	0.025	0.050
Mean±SD	0.0280±0.00282	0.0462±0.0035	0.0303± 0.0038	0.0767±0.1085

SD: Standard deviation

of sewage, fecal matter and other solid wastes (Masuda, 1964; US Public Health Services, 1962; Groth, 1975a, b) especially dead decaying organic matter, iii) deposition of atmospheric fluoride by precipitation or hydrolysis (Carpenter, 1969; Bressan *et al.*, 1974; Groth, 1975a, b) (iv) leaching of fluoride from fluoride rich rocks in the catchment area (Jacks, 1973; WHO, 2002) and (iv) leaching of calcareous soils rich in fluoride.

But decline in the concentration of fluorides during spring and summer may be due to, (i) uptake of fluoride by aquatic plants which increase in number during summer and (ii) uptake of fluoride by aquatic animals.

In fact fluoride recorded positive but significant correlation with BOD ($r = 0.423$, $p = 0.05$), conductivity ($r = 0.584$, $p = 0.01$), TDS ($r = 0.583$, $p = 0.01$), total phosphates ($r = 0.777$, $p = 0.01$), silicates ($r = 0.488$, $p = 0.05$), sodium ($r = 0.584$, $p = 0.01$), potassium ($r = 0.639$, $p = 0.01$) and iron ($r = 0.456$, $p = 0.05$) but negative and significant correlation with none. Besides fluoride values were found to be highly significant when different study stations and different months of the present study period were compared.

It is further revealed that a well marked seasonal variation in the concentration of fluoride at each of the four study stations is a witness of different levels of anthropogenic influences (Table 1). Consequently fluoride values have been observed to record differential minima and maxima at each of the four study stations.

The readings taken during study reveals that being under greater anthropogenic stress, station III has higher fluoride content followed by stations II, I and IV (Table 2).

DISCUSSION

With greater impact on human health, fluoride has gained significant importance in ecological assessment of natural waters. During the course of present investigation, fluoride concentration in Lake Mansar was observed to vary from 0.028 to 0.076 mg L^{-1}. But Carpenter (1969) recorded only 0.01 to 0.02 ppm average dissolved fluoride content in the major surface waters of the world. In the face of Carpenters observation, Lake Mansar contains approximately greater fluoride content than any other natural aquatic ecosystems of the world. However, the Kaminsky *et al.* (1990) observed that in United States individuals who consumed drinking water containing $\leq$4.0 mg L^{-1} fluoride did not show skeletal porosis. Thus in accordance to the Kaminsky *et al.* (1990), fluoride content in the water of Lake Mansar is not in the hazardous range.

Form the data it is revealed that Lake Mansar, also show seasonal fluctuation in fluoride concentration from 0.028 to 0.076 mg L^{-1}. A graphical representation of the annual data reveals that fluoride recorded bimodal peak, one during winter and the other during monsoons. The data on the whole reveals that the water body recorded higher fluoride fluctuations. This may be due to geothermal activity (because it is located in the seismic zone) and anthropogenic activity.

Geothermal activity as the source of fluorides has already been emphasized by Neuhold and Sigler (1960), Marier (1972), Rose and Marier (1977), IPCS (2002), WHO (2002) and Anonymous (2005). In addition to this the anthropogenic activity like fertilizers, weedicides, pesticides, remains of dead from cremation ground, fecal matter, soaps, detergents, pastes etc which are rich sources of fluoride also add to the fluoride concentration of the lake water. Although the lake waters have appreciable concentration of fluoride yet the same is within the permissible limits. But the fluoride built up in the lake is not a healthy sign as it has devastating effects on the biota in the from of dental caries, skeletal porosis, fractures etc and thus needs immediate precautionary measures to save the lake and its stakeholders from its lethal effects. Similar view point has been placed on record by Health Canada (1990) who classified fluoride as an essential element in the past but now it recommends that fluoride requirements should only be based on the beneficial effects on dental caries only.

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