ALUMNIUM AND SILICON CONCENTRATIONS IN SOME LAKE WATERS OF BANGLADESH

SHAMSHAD BEGUM QURAISHI
Chemistry Division, Atomic Energy Centre, Dhaka-1000, Bangladesh

ABSTRACT

A study on Aluminium (Al) and Silicon (Si) in different Lake waters in different seasons around Dhaka city was carried out using Inductively Coupled Plasma-Atomic Emission Spectrophotometry (ICP-AES). The highest concentration of Si was found in March and lowest was in August in case of all the Lakes and Si concentration decreased in the order of Rupnagar Lake> Gulshan Lake> Ramna Lake> Dhanmondi Lake. On the other hand, in some cases, comparatively higher concentrations of Al were found in March and then these decrease in June and again increase in August indicating these lakes may be getting contamination during rainy season. Among the four Lakes, Al concentration decreased in the order of Dhanmondi>Ramna>Gulshan>Rupnagar. This may be due to the formation of hydroxyaluminosilicate at high total silicon concentration. It is also notable that the level of Al in these four Lakes is much higher than the Bangladesh drinking water standard for Al.

Keywords : Lake water, seasonal variation, aluminium and silicon, ICP-AES

INTRODUCTION

Concern over the possible ecological effects of the increasing accumulation of metal contaminant in the environment is growing. For this reason, the monitoring of trace metals in surface water is essential. The European Union (EU), United States Environmental Protection Agency (US EPA) and various other government agencies have introduced guideline values relating to the maximum levels of contaminants, including trace metals. Aluminium and silicon are the third and second most abundant elements in the Earth's lithosphere (after oxygen) and their compounds are often found in natural waters. The presence of aluminium compounds in water used in kidney dialysis is associated with neurological disorders in patients receiving treatment [(1)]. The potential toxicity of aluminium to mammals has also generated considerable interest [(2)]. However, many analytical techniques like Total X-ray Fluorescence (TXRF), X-ray Fluorescence (XRF) and Proton Induced X-ray Emission (PIXE) cannot be employed for the analysis of Al and Si in water due to very low energy X-ray emission of these elements and tedious sample preparation. Inductively Coupled Plasma-Atomic Emission Spectrophotometry is now commonly used by analytical laboratories for the routine determination of many metals including Al and Si in water owing to its simultaneous measurement capability, relative freedom from matrix interference, wide analytical dynamic range, and high sensitivity[(3)].

In our laboratory, water quality parameters in drinking-lake-and river waters have been carried out and duely reported[(4-8)]. Recently, we reported levels of trace metal concentrations in some lakes in Dhaka City. It became necessary to carry out a detailed water quality assessment of these Lakes because of increased human activities during these days. The present paper deals with the study on the seasonal variation of Al and Si in some Lake waters around Dhaka City using Inductively Coupled Plasma-Atomic

Emission Spectophotometry (ICP-AES) and the effect of silicon concentration on aluminium bioavailability.

MATERIALS AND METHODS

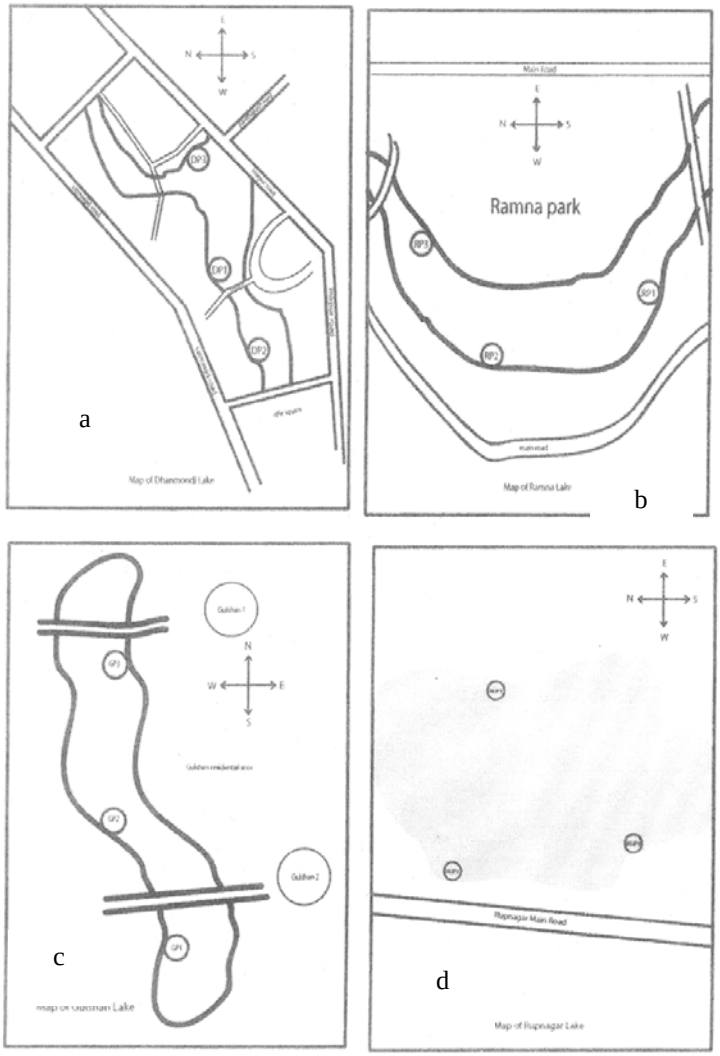
Reagents: The acids used were of extra-pure grade and deionized water used throughout the preparation of standard, samples and blank had an electrical conductivity less than 1μS/cm^2. Al and Si standards (1000 ppm) were obtained from SPEX Certiperp, Inc. (NJ,USA). The ICP-AES was calibrated by preparing calibration standard solutions from the stock standard solutions and SRM 1640 and 1643d were used to check the accuracy and precision of the analytical method. Standard reference materials were purchased from National Institute of Standards and Technology (NIST), USA.

Sample collection. Water samples (2L) were collected in a precleand (acid washed) polyethylene bottles form the four lakes in Dhaka city at three different locations of each lake during four seasons e.g., March, June, August and November during the period of November, 2003 to August, 2004. Lakes selected were Dhanmondi, Gulshan, Rupnagar and Ramna. Collected samples were filtered through the Whatman-41 filter paper. Details of each collection points are given in Fig. 1.

Analytical methodology and quality assurance : For the analysis of Al using ICP-AES JY 2000, hot plate digestion was used to digest and preconcentrate samples about 10 times. As part of the quality control protocol, analysis of reagent blank and certified reference material SRM 1640 (trace elements in water) and SRM 1643d (trace elements in water) were carried using ICP-AES. The results of the analysis of SRMs were well in agreement with NIST certified values (Table 1).

Table 1
Accuracy and precision of the method against certified reference materials

NIST SRM 1643d, Trace elements in natural water (μg/L)				
Elements	NIST certified values	Measured Values	CV%	RE%
Al	127.6 ± 3.5	115.6 ± 12.2	10.56	9.40
Si	2700	2880 ± 20	-0.69	-6.66
NIST SRM 1640, Trace elements in natural water (μg/L)				
Si	4730 ± 120	4550 ± 110	2.42	3.81



a = Dhanmondi lake b = Ramna lake c = Gulshan lake d = Rupnagar

Fig. 1. Sample Collection points of different lakes

RESULTS AND DISCUSSION

Surface water contains many dissolved inorganic and mineral substances, serving as nutrients for animal, aquatic and plant life, but due to human activity their concentration levels exceed the natural levels. These elements then exert adverse effects on living system. The continuous increase in concentrations within the cells of the organism can finally lead to death[9].

Aluminium and silicon are the most abundant elements in nature and are known as water quality parameters. However, Aluminium toxicity has been linked with a variety of neurological and behavioral disorders[9-10]. In this study the concentrations of Al and Si

and their variation in different seasons and different locations in Dhanmondi, Ramna, Gulshan and Rupnagar Lake have been investigated.

Concentrations of Al and Si in Lake water and their seasonal variations

Dhanmondi Lake: Dhanmondi Lake is located at the Dhanmondi residential cum commercial area of Dhaka City. Therefore, household as well as clinical and industrial wastes are dumped in this lake at many points as well as of construction works are going on in this area, which is the main source of Al and Si. Concentrations of Al and Si and their seasonal variations are shown in Fig.2. It can be seen from the Fig.2 (A) and Fig. 2 (B) that there is no significant difference of Al and Si content between the three collection points; however, significant variation is found between four seasons. In case of Si, maximum (5.25 mg/L) and minimum (3.57 mg/L) concentrations were observed in March and August respectively. During winter, the water level is reduced; therefore, the metal content can become concentrated to some extent. On the other hand, during the rainy season, the water level is increased, and as a result, metal concentrations become diluted. However, in case of Al highest concentration was found in March and lowest in November not in August. In August, a much higher concentration was observed which may be due to a flood which washed-out most of the nearby area and carried waste into the lake. The mean Al concentration values obtained for Dhanmondi Lake waters were higher than the values reported for two acidic lakes (Blue Mountain Lake and Lake Success) in the northeastern USA[11], 36 lakes in Lapland [12] and Tuskegee lake in the southastern USA[23].

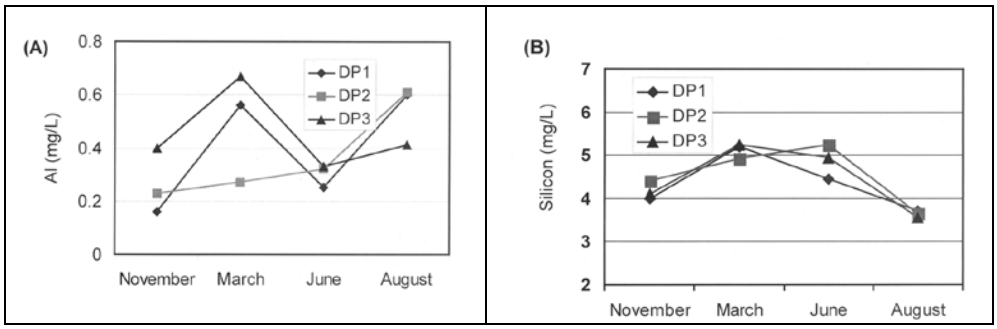


Fig. 2. Seasonal Variation of Al and Si in water at different locations of Dhanmondi Lake.

Rupnagar Lake : Rupnagar Lake is located at the Mirpur residential area around Dhaka city. It can be observed from Fig. 3 that there is no significant difference of Al and Si content between the three collection points. However, significant variation was observed with the change of seasons. The highest concentration of Si was found in March and lowest in August, indicating dilution during the rainy season. However, the pattern of Al seasonal variation in this case is quite different from that of Dhanmondi Lake. The highest concentration (0.23 mg/L) was found in August and lowest was in November, which indicates that water of this lake may have been contaminated by Al during a flood. However, a very sharp decreasing tendency of Al was observed during August to November, which may be due to reaction of silica with aluminium to form fine sediments in presence of microorganisms [10]. On the other hand, the average values for this metal in Rupnagar Lake water samples were consistently lower than the corresponding reported

values for the Tuskegee lake in the southeastern USA [13] but were comparable with the Lake Success in the northeastern USA [11] and 36 lakes in Lapland [12].

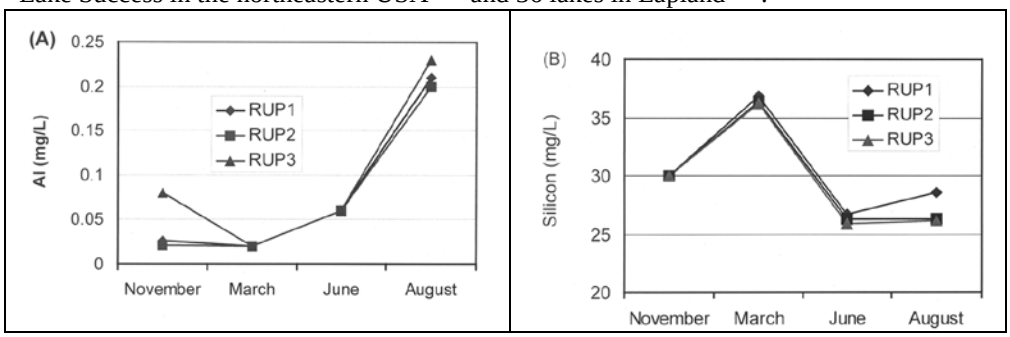


Fig. 3. Seasonal Variation of Al and Si in water at different locations of Rupnagar Lake.

Gulshan Lake : Seasonal variations in Al and Si in Gulshan lake water are shown in Fig. 4. It can be seen from the Fig. 4A that there is no significant difference of Si content between the three collection points; however, significant variation is found between four seasons. The maximum (32.7 mg/L) and minimum (11.42 mg/L) concentrations were observed in March and August respectively. However, it can be observed from Fig. 4B that there are some variations of Al content between three collection points and between four seasons. The highest concentration was observed in March and the lowest in November. The average concentrations of aluminium in Gulshan Lake were higher than the reported values for Blue Mountain Lake and Lake Success) in the northeastern USA[11] and 36 lakes in Lapland [12] but the mean value of Al was comparable with the Tuskegee Lake in the southeastern USA [13].

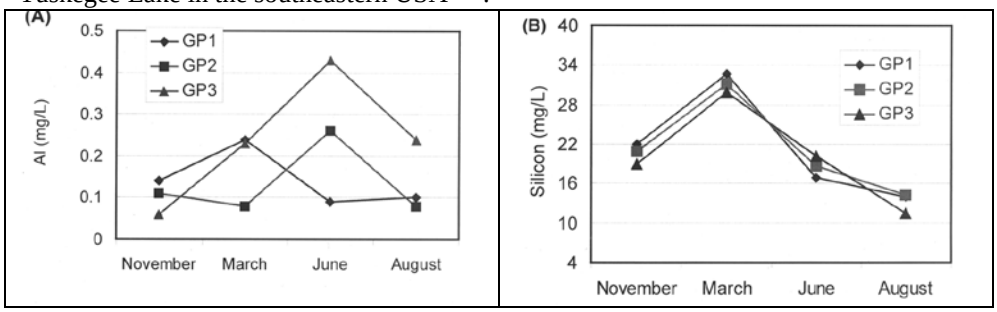


Fig. 4. Seasonal Variation of Al and Si in water at different locations of Gulshan Lake.

Ramna Lake : As can be seen in Fig. 5A and 5B that the highest concentrations of Al and Si were found in March and the lowest were in November for Al not in August. In August, much higher concentrations of Al were observed which can be attributed to land runoff due to excessive rainfall in this season. The mean Al concentration values obtained for Ramna Lake water samples were also higher than the values reported for two acidic lakes (Blue Mountain Lake and Lake Success) in the northeastern USA [11], Tuskegee lake in the Southeastern USA[13] and 36 lakes in Lapland [12].

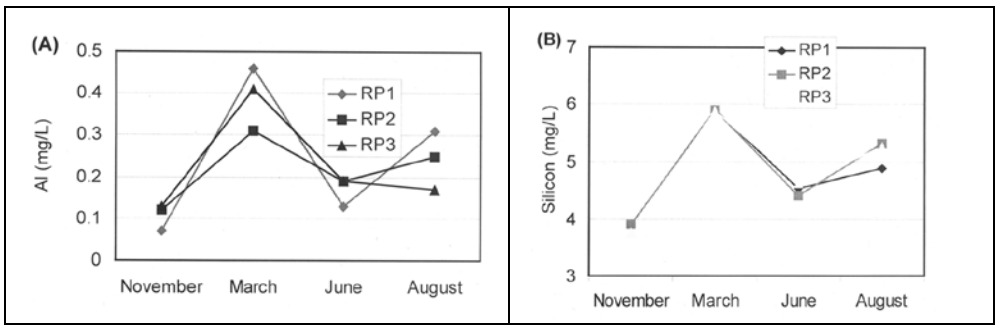


Fig. 5. Seasonal Variation of Al and Si in water at different locations of Ramna Lake.

All Lakes water exceeded the Bangladesh and USEPA drinking water standards (which is set at 0.2 mg/L) for Al at least for one season. These samples may not be suitable for human consumption and these lakes get more contaminated during the rainy season. The contamination of surface water as a result of runoff from municipal and industrial discharges may further increase the level of Al in water. There is a considerable variation in the content of Al and Si from one Lake to another. In case of seasonal variation, the highest concentration of Si was found in March and lowest in August for three lakes except Ramna lake. However, seasonal variation is very scare for Al between four Lakes.

ACKNOWLEDGEMENT

The authors would like to thank the colleagues of the Chemistry Division, Atomic Energy Centre, Dhaka, for their co-operation during the course of this study.

REFERENCES

1. EJ UNDERWOOD, "Trace Elements in Human and Animal Nutrition." p 1-473. Academic press, New York. 1971.
2. D.A. HADI, S. A. TARAFDER, S. AKHTER, *Bang. J. Sci. Ind. Res*., **XXXI**,41-46, 1996.
3. M. THOMPSON, "Handbook of Inductively Coupled Plasma Spectrometry", Blackie & Son Ltd, New York, 1989.
4. F. B. A. MAROOF, D. A. HADI, KHAN, *Nucl. Sci. Appl.*, **16&17**, 145-146, 1985.
5. A. H. KHAN, M. ALI, S. K. BIASWAS , D. A. HADI, *Sci Tot. Environ*., **53**, 121-130, 1986.
6. D. A. HADI, S. A. TARAFDER, M YONUS, *Nucl. Sci Appl*., **3**, 73-75, 1991.
7. M. M. RAHMAN, *M. Sc Thesis*, Department of Applied Chemistry and Chemical Technology, Dhaka University, 1998.
8. L. S. BANU, *M. Sc Thesis*, Jagannath College University, Bangladesh, 1999.
9. A. S. PRASAD, "Trace elements in human health and disease," Vol II, pp. 1-474, Academic Press, Inc., NY, USA, 1976.
10. R. W. EUGENE, "Applications of Environmental Chemistry," Lewis Publishers, 2000.
11. M. SPRENGER, A. MCINTOSH, T. LEWIS, *Arch. Environ. Contam. Toxicol*., **16**, 383-390, 1987.
12. J. MANNIO, O. JARVINEN, R. TUOMINEN, M. VERTA, *Sci. Tot. Environ*., **160**, 433-439, 1995.
13. A. IKEM, NO. EGIEBOR, K. NYAVOR, *Water Air Soil Pollut*., **149**, 51-75, 2003.
14. JD. BIRCHALL, C. EXLEY, JS. CHAPPEL, MJ. PHILIPS, *Nature* **338**, 146-148, 1989.

15. JD. BIRCHALL, C. EXLEY, JS. CHAPPEL, *J. Inorg. Biochem.*, **36**, 47-349, 1989.
16. C. EXLEY, JD. BIRCHALLI, *Polyhedron*, **11**, 1907, 1992.

Journal of Bangladesh Academy of Sciences, Vol. 32, No. 1, 33-39, 2008