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Assessment of Trace and Major Elements in Donghu Lake Hubei Province, China

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Abstract: A study was undertaken to determine the major and trace elements in Donghu lake. The total concentrations of a large suite of elements (Al, As, B, Ba, Ca, Cr, Cu, Fe, K, Mg, Mn, Na, P, S, Si, Sr, V, Zn) were determined using spectroscopic techniques. The concentrations of trace and major elements were measured in water samples collected from five locations of Donghu lake from May to October 2007. Since, the surface water is polluted by the discharge of municipal and industrial wastewaters, it is suffering lack of clean water in Donghu, although there is adequacy of total water resource. With the rapid growth of economy in the area, the water pollution seems getting more and more serious. Normally, self cleaning effect is one of the important functions of freshwater system, which some harms posed by pollutants can be alleviated in water. But the human activities decrease it greatly and as a result, the water quality declined, freshwater system eutrophicated and degraded. The variability observed within the water samples is closely connected to the sampling locations; hence, it is primarily a consequence of discharge influent. The trace element levels, in particular those of heavy metals are moderate suggesting an origin from anthropogenic contamination rather than from natural sources.

Key words: Major elements, trace elements, Donghu lake

INTRODUCTION

Surface water is an essential component of the earth's hydrosphere and an indispensable part of all terrestrial ecosystems. Water is needed in all aspects of life. An adequate supply of water of suitable quality makes a major contribution to economic and social development. However, many parts of the world are facing the pollution of fresh water. Humans have been polluting their water since civilization began leading to problems of scarcity and contaminations are becoming severe.

The distribution of major and trace elements in the separate components of the Donghu ecosystem represents the result of natural processes. Natural background levels of trace and minor elements, particularly the potentially toxic heavy metals, need to be determined. The identification of possible sources and pathways of major and trace elements is particularly useful for the definition of surface water quality. For this reason a comparison of results obtained over a period of six months is used to detect the variation of trace and major element in dinghy. In this study, we have examined the distribution of a series of metals in freshwater collected in 5 sampling stations, from July to October 2007. The concentrations of 18 elements (Al, As, B, Ba, Ca, Cr, Cu, Fe, K, Mg, Mn, Na, P, S, Si, Sr, V, Zn) were determined in the lake waters. The water samples were analyzed by and ICP mass spectroscopy. Trace and major elements are natural components of the hydrosphere and many are necessary, in minute quantities, for the metabolism of organisms (e.g., arsenic, copper, iron, etc.) (Ward, 1995). However, elevated concentrations in tissues induce toxicity through interference with enzymatic activity, among others (Ward, 1995). In some cases, the difference between deficiency and excess (toxic) levels may be as small as a few g g^{-1} (Plant *et al.*, 2001). Several metals, such as cadmium, mercury and lead, are considered highly toxic (Demayo, 1980). Those do not normally participate to metabolism and, at least in humans, are accumulated throughout the entire life of an individual. Industrial development and urban expansion frequently are cause to a rise in heavy metal levels in the environment (Rainbow, 1985). The quality of drinking water affects the day to day health (Dufour, 1982). Water quality and environmental pollution studies have gained increasing attention both nationally and

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internationally in the last 10-15 years. A large number of studies have been reported for trace elements analysis of water in recent years (Hacisalihoglu and Eliyakut, 1992; Sharma *et al.*, 1989) Trace and major elements in lakes are a consequence of catchment bedrock geochemistry, within-channel particulate-dissolved interaction, atmospheric deposition and anthropogenic activity (Leckie and James, 1974). Sources of anthropogenic contamination for the aquatic environment include urban sewage (arsenic, chromium, copper, manganese), biomass combustion (arsenic, mercury, selenium), metal processing (cadmium, lead, selenium, chromium, antimony, zinc) and seepage from refuse deposits (arsenic, manganese, lead) (Nriagu and Pacyna, 1988). For obvious reasons, acute poisoning of aquatic organisms has been intensely studied (e.g., Mance, 1987). During last 5 decades, human population has increased sharply in the catchments. This increase in population has adversely affected the water quality of the lake. Increasing anthropogenic pressure in the catchments and even increasing tourist influx have also contributed greatly to the pollution in the lake. Recent data revealed that the level of eutrophication of Donghu is consistently increasing. This is evidenced by several parameters of water quality.

MATERIALS AND METHODS

Site description: Water sample were collected from 5 sampling stations in Donghu, it is a dammed lake in the middle reach of the Yangtze River (Liu, 1984). It is to the northeast of the urban district of Wuhan city and to the south of the Wuhan Iron and Steel Company and the Wingspan Solid Fired Power Station, a heavy industrialized district. The surface area and the average depth of the lake are 27.9 km^2 and 2.6 m, respectively. The urban expansion and industrial development around the lake began in the 1950's. Since, then, a large amount of waste water has been released into the lake from the residential district by many small outlets along the bank especially the southwest bank of the lake. The drainage volume has been beyond the self purification capacity; meanwhile, a great number of atmospheric particles arising from the industrial processes such as high combustion of coal based power generation, iron and steel manufacture and non-ferrous metal smelting fall in the lake and sometimes, the industrial waste water is released into the lake from the industrial district. Lakes provide so much in the way of recreation; fishing, boating and swimming are just a few of the activities you are likely to see. Lakes and their shorelines also provide important wildlife habitat for both aquatic and terrestrial animals. Lakes even help protect water quality. Eroded sediments, debris and other pollutants washed from watersheds are deposited in lake by inflowing streams.

Sampling procedure and water sample preparation: Five sampling stations were established and referenced so that the same locations were sampled each month. Field measurements were taken at each location and included air temperature, water temperature, pH, Eh and conductivity. Conductivity and temperature were measured using a YSI 85D oxygen/temperature/ conductivity meter. Calibrations were made before using the equipment, pH was determined using a hand held pH meter. All water samples were taken with a 1 L polyethylene bottle which had been rinsed several times with ultra pure water and then rinsed with the water sample before collection. The water samples were immediately filtered through acid washed 0.45 μm cellulose acetate filters into pre-cleaned polyethylene bottles and transferred to the laboratory for analysis. Samples were processed in a clean environment under a Class-100 laminar flow bench-hood. The water samples were acidified with purified nitric acid and analyzed by, atomic mass spectroscopy .The standard solutions for the instrumental calibration were prepared in aliquots of calibration blank. This experimental technique has been largely used in environmental studies (Filgueiras *et al.*, 2002) and several schemes exist (Smichowski *et al.*, 2005).

Standard solution and reagents: Stock standard solutions (1000 μg mL^{-1}) of trace and major elements were obtained from the China University of Geosciences. Working standard solutions were obtained by appropriate dilution of the stock standard solutions. All the reagents used were of analytical grade or better. Doubly distilled water was used throughout the research. The following buffers were used to control the pH of the solutions: hydrochloric acid-glycine (pH 1-3), sodium acetate-acetic acid (pH 3-6), ammonium acetate-ammonia (pH 6-8) and ammonium chloride-ammonia (pH 8-9).

RESULTS AND DISCUSSION

The concentrations of elements in surface water are presented in Table 1 and 2.Water of the Donghu is basic and pH; 5.30-8.60, conductivity (μmho cm^{-1}); 2290-2440. The average concentrations of trace and major elements in μg L^{-1} were Al 0.11, As 0.05, B 0.06 l, Ba 0.10, Ca 52.53, Cr 0.03, Cu0.05l, Fe 0.16, K 9.73, Mg14.64, Mn 0.14, Na 33.54, P1.19, S 20.42, Si 3.79, Sr 0.03, V 0.02 and Zn 0.35. In Donghu, monthly changes in both major and trace element concentrations were negligible and almost within

Table 1: Concentrations of Al, B, Ba, Ca, Cr, Cu, Fe, in Donghu lake (mg L^{-1}) in 2007

	Sample no	Al	As1	B	Ba	Ca	Cr	Cu	Fe	K
	1	0.01	0.01	0.05	0.06	44.42	0.00	0.02	0.12	4.30
	2	0.02	0.01	0.04	0.05	50.64	0.00	0.01	0.00	5.30
	3	0.02	0.01	0.04	0.06	46.12	0.00	0.02	0.00	3.96
	4	0.01	0.00	0.03	0.08	46.42	0.00	0.01	0.05	3.49
May	5	0.02	0.01	0.04	0.07	50.57	0.00	0.03	0.00	8.52
	6	0.02	0.01	0.05	0.07	51.86	0.00	0.03	0.11	4.92
	7	0.02	0.01	0.04	0.05	51.78	0.00	0.02	0.01	5.86
	8	0.02	0.00	0.04	0.06	43.30	0.00	0.03	0.01	4.06
	9	0.02	0.00	0.02	0.09	50.56	0.00	0.02	0.09	3.83
June	10	0.01	0.01	0.04	0.09	51.63	0.00	0.04	0.02	8.78
	11	0.01	0.00	0.06	0.06	52.53	0.00	0.00	0.08	5.00
	12	0.01	0.01	0.05	0.05	49.63	0.00	0.00	0.03	5.71
	13	0.01	0.00	0.04	0.07	41.06	0.00	0.00	0.07	4.32
	14	0.00	0.00	0.03	0.09	49.59	0.00	0.00	0.06	4.11
July	15	0.15	0.01	0.04	0.07	41.19	0.00	0.00	0.16	9.33
	16	0.03	0.02	0.04	0.07	43.70	0.00	0.05	0.03	4.80
	17	0.03	0.03	0.04	0.05	48.63	0.00	0.02	0.01	7.00
August	18	0.03	0.02	0.04	0.07	39.71	0.00	0.02	0.01	3.96
	19	0.03	0.03	0.02	0.10	43.87	0.00	0.01	0.01	3.98
	20	0.03	0.03	0.02	0.10	43.43	0.00	0.02	0.01	3.84
	21	0.04	0.02	0.04	0.06	34.59	0.00	0.02	0.01	4.52
	22	0.03	0.03	0.04	0.05	46.19	0.01	0.02	0.01	6.18
September	23	0.06	0.03	0.03	0.07	39.42	0.01	0.02	0.01	3.87
	24	0.06	0.03	0.02	0.07	39.06	0.02	0.02	0.01	3.91
	25	0.05	0.02	0.04	0.08	41.45	0.03	0.02	0.01	9.08
October	26	0.06	0.02	0.04	0.05	32.07	0.03	0.02	0.02	4.32
	27	0.03	0.03	0.04	0.07	46.71	0.03	0.02	0.01	7.53
	28	0.05	0.03	0.03	0.07	38.55	0.02	0.02	0.14	4.10
	29	0.06	0.03	0.03	0.07	28.85	0.02	0.02	0.02	4.03
	30	0.05	0.05	0.04	0.07	41.56	0.01	0.02	0.02	9.73

Table 2: Concentration of Mg, Mn, Na, P, S, Si, Sr, V, Zn, in Donghu Lake (mg L^{-1}) in 2007

	Sample no	Mg	Mn	Na	P	S	Si	Sr	V	Zn
	1	11.07	0.09	24.31	0.24	20.42	1.69	0.28	0.00	0.00
	2	11.43	0.00	25.65	0.71	17.85	1.93	0.28	0.01	0.01
	3	10.58	0.00	19.17	0.06	15.97	0.67	0.25	0.00	0.00
	4	10.24	0.02	17.11	0.03	15.49	0.76	0.23	0.00	0.01
May	5	14.61	0.00	31.85	0.40	18.92	3.29	0.27	0.00	0.00
	6	11.48	0.14	26.56	0.65	14.30	1.99	0.30	0.00	0.02
	7	11.61	0.00	27.33	0.87	16.11	0.58	0.29	0.00	0.01
	8	10.68	0.02	19.44	0.08	16.01	0.09	0.25	0.00	0.01
	9	10.78	0.03	17.71	0.04	16.26	1.40	0.25	0.00	0.01
June	10	14.64	0.04	33.54	0.38	17.51	3.12	0.28	0.00	0.01
	11	11.27	0.13	26.28	0.98	13.15	2.06	0.29	0.00	0.02
	12	11.14	0.04	26.52	0.69	15.94	0.44	0.29	0.00	0.01
	13	10.99	0.04	19.69	0.11	15.53	0.54	0.26	0.00	0.01
	14	11.16	0.05	17.14	0.02	15.69	2.20	0.26	0.00	0.00
	15	14.03	0.02	33.33	0.57	15.38	2.27	0.26	0.00	0.00
July	16	9.81	0.06	24.02	0.28	14.80	2.10	0.24	0.01	0.12
	17	10.86	0.00	26.03	1.14	15.06	1.21	0.26	0.02	0.01
	18	9.71	0.04	20.42	0.21	14.95	1.19	0.23	0.02	0.03
August	19	9.98	0.05	18.69	0.12	12.04	3.16	0.23	0.01	0.02
	20	9.88	0.05	18.70	0.12	11.95	3.14	0.24	0.01	0.02
	21	8.87	0.09	22.36	0.22	14.88	1.79	0.23	0.02	0.02
	22	9.68	0.01	23.63	1.01	13.53	0.59	0.26	0.02	0.14
September	23	9.44	0.00	19.61	0.20	14.51	1.26	0.23	0.02	0.07
	24	9.46	0.00	18.23	0.07	11.21	3.06	0.22	0.01	0.21
	25	11.42	0.02	26.64	0.36	13.72	2.40	0.24	0.02	0.28
	26	8.63	0.12	22.22	0.31	14.53	2.82	0.22	0.02	0.35
	27	10.42	0.05	25.18	1.19	13.43	0.80	0.27	0.02	0.27
October	28	9.33	0.06	20.02	0.30	13.75	1.94	0.24	0.03	0.18
	29	8.91	0.05	17.99	0.14	10.43	3.02	0.19	0.02	0.25
	30	11.82	0.08	27.12	0.68	12.74	3.79	0.24	0.02	0.11

the precision of analytical methods, indicating a highly uniform water composition. Cr was not detected in May, June, July and August at all sites, while vanadium was only detected in sites N°2 during the first three months.

The concentrations of trace and major elements in water varied from each other depending on the different site. The Zn, Fe, Mn, As, concentrations in lake water in the five sampling sites are within the TSE-266, EPA and EC-1998 standards. Although, the concentration of Mg in the lake water is much higher than the TSE-266 standards, the concentration of Ca in the lake water is much lower than the TSE-266 standards. The highest concentrations of Al, As, B, Ba, Ca, Cr, Cu, Fe, K, Mg, Mn, Na, P, S, Si, Sr, V and Zn) were found in water sample number 15, 30,11, 21, 12, 26, 16, 15, 30, 5,6, 10,27, 1,30, 6, 29, 27, respectively (Table 1 and 2). None of these was from the Donghu main lake; all of them are from its bays, this is due to twelve sets of small scale plots and one set of medium scale plot system of downflow-upflow constructed wetland systems were constructed near the inlet of Donghu Lake, the influent of the plots were from the lake. More than two years' operation revealed that the constructed wetland has remarkable removal of pollutants in Donghu main lake.

The concentration of Ca in investigated water samples were higher than the average ranging from 7-31 $\mu g\ L^{-1}$ in fresh water reported by (Wetzel, 1975). The Ca to Mg ratio in lake's water ranged from 2.94 to 4.77 and the maximum was higher than typical natural waters (2-4) ones. It is due to nearby prevalence of mountain with high calcium contents. Calcium is responsible for the hardness of the water. The hardness of the water leads to encrustation of water supply structure. It is seen that aluminum contents are in the range of 30-60 ppb which is large compared to the desirable BIS limit (30 ppb).

In general, sampling sites contained high concentrations of Ca, Sr, S, Na, K, Mg and Zn, S, Si but lower concentrations As, B, Ba, Cu, Al, P, Mn and much lower concentrations Fe, Mn and Cr. Water of the lake show lower concentrations of heavy metals and high concentration macronutrients when compared to the EC-1998 standard, indicating metal toxicity in this lake additional inputs of domestic activities carried by sewage water are causing the eutrophcation of the lake.

A recent study explains that the levels of heavy metals in water of anthropogenic lakes differing in stage of acidifications and found the following concentrations (in $\mu g\ L^{-1}$): 2.4-12 K, 23-98 Ca, 14-60 Mg, 2-4790 Fe (in $\mu g\ L^{-1}$): 13-65 Co, 130-1480 Mn, 4-55 Ni, 86-751 Zn, 7-198 Cu (Samecka-cymerman and KemPers, 2001). Differences between our data and those of partly originates probably from differences in geological mining history of cites. If one considers that the studied area is a lake constrained by urban and domestic activities, we can understand these high values. The concentrations of Cu, Fe, Mn and Zn in lake water obtained in this study are higher than those reported in Ataturk Dam Lake (Karadede and Unlu, 2000).

Kishe and Machiwa (2003) investigated concentrations of trace elements in Lake Victoria (Tanzania) and found following highest concentrations (in mg kg^{-1}) 26.1±4.8 Cu, 45.4±13.1 Zn, at approximately 25 m from the shoreline. In this study, was found highest concentrations (in mg kg^{-1}) 48±2.4 Co, 79±9.1 Cr, 30 000±988 Fe and 625±22 Mn, 210±13 Zn, 130±21 Ni and 64±11 Cu. The average levels showed that concentrations of trace elements varied from each other depending on the different sites. The sources of trace elements were mainly industrial and domestic waste discharges. In some cases reported to contribute significantly to the level of race elements in the aquatic environment (Talbot and Chegwidden, 1983). The high level of Zn in lake water from the city area sampling stations reflects the presence of lake polluting activities in the city. The concentrations of toxic metals (Cr, Fe and Mn) were found to be much lower than the earlier study lake is presently being regulated by China environmental protection agency.

According to, the research made, study has shown that Donghu Lake is polluted with moderate trace elements, suggesting an origin from anthropogenic activities. Differences between Donghu main lake and its bays are significant elements are higher in four bays of Donghu. This slight variation may be due to larger water flow from municipal waste discharged discharged in these bays, possibly carrying slightly higher concentrations of elements in solution.

CONCLUSION

Water samples from Donghu lake show that those sites have been contaminated by trace elements and the contamination might start before industrialization. And the closer the site to the pollution sources, the heavier the contamination.

Local geology sources can make influence element concentrations and the influence varies in different locations due to the differences of geology and geochemical processes in different areas.

Catchment erosion affect trace and major element concentrations in the lake .The affection depends on the element level in the catchment soils, which washed into the lake and the erosion rates. If heavy contaminated soils is washed in to the lake, it could enhance lake pollution level, on the contrary, less or no contaminated soils washed into the lake, it could dilute pollution signal recorded by the lake and contaminated soils in the catchment can turn into pollution sources for the lake.

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