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Characteristics of phosphorus, fluorine and sulfur in surface sediments from Yangzonghai lake, China

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ABSTRACT

The content and characteristics of phosphorus, fluorine and sulfur in surface sediments from Yangzonghai Lake in Yunnan, China were analyzed and the single standard index to assess the contamination degree was utilized. The results showed that the average concentrations of phosphorus, fluorine and sulfur in surface sediments of Yangzonghai Lake were up to 1041.3, 1074.8 and 2743.1mg/kg, respectively. It is considered that human activities, such as sanitary waste, production waste, process gas, powerboat, fish culture in net pen were the major sources of phosphorus, fluorine and sulfur in Yangzonghai Lake. The mean standard indexes of phosphorus, fluorine, sulfur were up to 1.74, 1.34 and 1.31 respectively, which indicated that the contaminations of phosphorus, fluorine and sulfur were all serious in Yangzonghai Lake. The control of pollutant sources and the treatment of sediments in the high contamination regions of Yangzonghai Lake should be implemented urgently.

KEYWORDS

Phosphorus;
Fluorine;
Sulfur;
Surface Sediment;
Yangzonghai Lake.

INTRODUCTION

Sediment provides nutrient substances to various living creatures in the lakes and stores various pollutants. Accordingly, it is an important part of Lake Ecosystem. However, the pollutants stored in the sediment can be released through a series of physical, chemical and biological processes, and this potentially threatens Lake Ecosystem[1-3]. After pollutants have entered into the lake, its distribution in the water is generally irregular, while that in the sediment shows obvious regularity of pollution characteristics[4]. Therefore, mastering the pollution and distribution of pollutants in the sediments is of important instructive significance to investigate the environmental quality of lakes and the pollution history of water, judge pollution sources as well as prevention and control pollutions in lakes[5].

Phosphorus, fluorine and sulfur are important environmental factors in the lake sediments. Phosphorus is an important indicator about eutrophication of water; that in the sediments is an important recharge source for the phosphorus in the overlying water, and it's one of the important factors affecting the eutrophication of lakes[6]. Fluorine is toxic to many living creatures. Moreover, it's easily concentrated in the bodies of living creatures, and it potentially threatens the health of human

beings through aquatic animals and plants[7]. Not only can sulfur affect water acidification, but also it's one of the important factors for controlling the oxidation-reduction system in the sediments. Furthermore, it will affect the migration of other pollutants such as heavy metals[8].

Yangzonghai Lake is one of the nine plateau lakes in Yunnan Province, China, and is a freshwater lake which the local residents rely for existence. In the last tow decades, with the rapid development of industry, mining, fishery and tourism, continuously increasing pollutants have been entering into the lake and accumulating in the sediments. In this study, through the investigation on the contents of total phosphorus, fluorine and sulfur in the surface sediments of the Yangzonghai Lake, the pollution characteristics were discussed; the pollution sources were analyzed, and the pollution was assessed with the single standard index, so as to provide scientific evidences for the correct evaluation and improvement on the environmental quality of the Yangzonghai Lake as well as pollution treatment and protection.

MATERIALS AND METHODS

Yangzonghai Lake (E102°592 -103°022 , N24°512 - 24°582) is a fresh water lake indispensable for local residents. 2.5km wide from east to west and 12.7km long from north to south, the spindle-shaped lake has a shoreline of 32.3km, a surface area of 31.9km^2 (at the water level of 1, 770m) and a drainage area of 192 km^2. With an average depth of 20m, the deepest part being 29.7m, it has a storage capacity of 604 million m^3 and a water exchange period of 13 years[9,10]. The water supplied to the lake is mainly from natural precipitation, the catchment between Great Yangzong River and Qixing River, the artificial water supply from Baiyi River, and groundwater. Tangchi River is the only outlet, and the river flows into the Nanpanjiang River finally.

From April 2 to April 4, 2009, a total of 25 groups of 0-5cm surface sediment samples were collected from the Yangzonghai Lake with a grab sampler (Figure 1). After well mixed, these samples were placed in polythene plastic bags to naturally dry in the shade in the laboratory. Then, by eliminating plant and animal residues and stones, the samples were grinded. Through 200-mesh screening, they were placed in a 105 ! oven to be dried for 8 hours, taken out, and put into dry basins. 4.00g of soil samples were weighted and squashed, and elements were determined with a PW4400 X-ray fluorescence spectrometer in accordance with *JY/T016-1996 General Method of Wavelength-Dispersive X-ray Fluorescence Spectrometry* published by the State Education Commission of China.

a:Great Yangzong River; b:Qixing River; c:Luxichong River; d:Baiyi River; e:Tangchi River

Figure 1 : The sampling stations in Yangzonghai Lake

RESULTS AND DISCUSSION

Contents of contaminants in sediments

The content of total phosphorus in the sediments from the Yangzonghai Lake was between 592.3-2021.1mg/kg (Figure 2) with the average value of 1041.3mg/kg. The phosphorus contents of most samples were lower than 1000mg/kg. The minimum value was sampled from point N09 along the northwestern shore, while the maximum value was sampled from point N22 along the southern shore of Tangchi Town. The content of total fluorine was between 471.7-1979.9mg/kg with the average value of 1074.8mg/kg and most concentrated between 750-1500mg/kg. Except for the minimum value at point N14 around Huangshuidong along the eastern shore, the fluorine

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contents of other samples all exceed the background value of soil environment in Yunnan province of 525mg/kg[11], and the maximum value was sampled from point N12 near Sanshimu along the western shore. The range of total sulfur contents was between 563.8-13530mg/kg with the average value of 2743.1mg/kg. Among all, the contents of 23 samples were higher than the average value of global soil background of 700mg/kg[12]. The minimum value was sampled from point N09 along the northwest shore, while the maximum value was sampled from point N01 around Tangeying along the southern shore. The coefficients of variance about these three elements contents were 37%, 32% and 94% respectively, and they were relatively great. This reflected that there were differences with various degrees in spatial distribution, and that in the distribution difference of sulfur was the most significant.

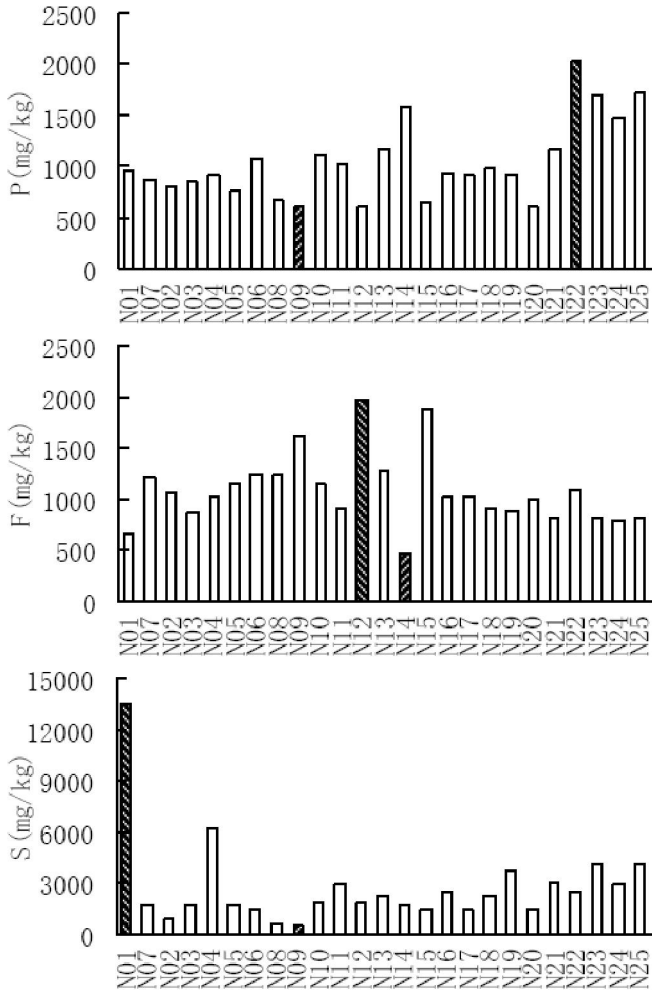

Figure 2 : Concentrations of P, F, S in sediments from Yangzonghai Lake

Spatial distribution and origins of contaminants

The spatial distributions of phosphorus, fluorine and sulfur in the sediments from the Yangzonghai Lake were shown in Figure 3.

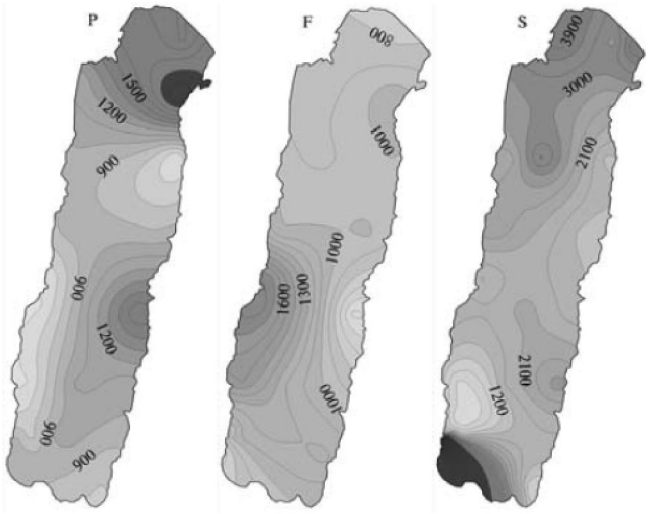

Figure 3 : Isograms of contaminants in sediments from Yangzonghai Lake (mg/kg)

The high values of phosphorus were mainly centralized in the north of the lake and around Huangshuidong in the east, while the contents along the western and southern shores were comparatively low. Tangchi Town in the north was the area in which human activities were the most concentrated, and its main industries were coal steam-electric plant, coal mine, phosphate fertilizer manufacturing plant and many warm spring resorts. The discharge of domestic sewage and industrial wastewater was one of the main sources of phosphorus in the sediments. In addition, motor vessels, cage fish culture, water loss and soil erosion caused during development also contributed to the accumulation of phosphorus in the sediments[13,14].

The high values of fluorine were mainly centralized near the Sanshimu area along the western shore; the contents were not greatly different in other regions, and the content around Huangshuidong along the eastern shore was lowest. This showed the characteristic of single pollution source. The only industry around the area with high fluorine content was an aluminum manufacturing plant; fluorides and fluorine-contained dust were the main pollutants generated by electrolyzing aluminum[15]. The fluorine entering into the Yangzonghai Lake through atmospheric deposition and sewage dis-

charge accumulated in the sediments around the plant area.

The high values of sulfur were mainly centralized both along the southern and the northern shores where human activities were concentrated. This reflected that it was also mainly affected by human activities. The main industries around Tangeying along the southern shore were vitriol manufacturing plant and refractory plant, and sulfur accumulation with extremely high concentrations in this area was caused by the discharge of waste gas and water from these plants. Sulfur enrichment along the northern shore was closely related to coal-burning in the coal steam-electric plant and other industries as well as sanitary waste. In addition, cage fish culture was also one of the sulfur sources[16].

One part of the phosphorus, fluorine and sulfur in the sediments was from the natural environment, and the remaining part was from human activities. It was reflected from the relatively high content differences and obvious pollution patterns that, the pollution caused by human activities played the leading role in the accumulation processes of phosphorus, fluorine and sulfur in the surface sediments of the Yangzonghai Lake.

Assessment of pollution degree

In order to assessment the pollution degrees of phosphorus, fluorine and sulfur in the sediments of the Yangzonghai Lake, the single standard index method was utilized. The following relationship existed in the standard index of single pollution factor *i*:

$$S_i = C_i / C_s \quad (1)$$

In the formula, C_i was the measured value of the evaluation factor *i*; C_s was the evaluation standard value of the evaluation factor *i*; S_i was the single standard index; that the value of S_i was greater than 1 represented that there was pollution, and greater S_i indicated more serious pollution. At present, there was no unified standard for the quality evaluation of phosphorus, fluorine and sulfur in sediments. In this study, the evaluation of total phosphorus pollution was conducted with the total phosphorus standard (600mg/kg) in the guideline which would cause the lowest level of ecological toxicity effect and was issued by the Ministry of Environment and Energy of Ontario, Canada (1992)[17]; total fluorine was evaluated with the average total fluorine (800mg/kg) in the soil of fluorosis area in China[18], and total sulfur was evaluated with three times of the average value of global soil background (2100mg/kg).

The results were shown in TABLE 1, and the standard indexes of total phosphorus in the surface sediments of the Yangzonghai Lake were between 0.99-3.37 with the average value of 1.74. Among all, the standard indexes of 22 samples exceeded 1, and this indicated that the environmental quality of Yangzonghai Lake was seriously polluted by phosphorus. Cyanobacteria bloom happened in the Yangzonghai Lake in 1997. Although the water quality had recovered at present, the accumulation of phosphorus in sediments was still an important environmental problem. The standard index range of total fluorine was between 0.59-2.47 with the average value of 1.34, and the standard indexes of the 22 samples were greater than 1. This indicated that there was also serious fluorine pollution in Yangzonghai Lake. The standard indexes of sulfur were between 0.27-6.44 with the average value of 1.31; the standard indexes of 12 samples were greater than 1, and its average pollution degree was slightly lower than those of phosphorus and fluorine. However, on point N01 near Tangeying, the standard index of sulfur was as high as 6.44, and the pollution degree was extremely serious.

TABLE 1 : The single standard indexes of Contaminants

Sample	Standard Index			Sample	Standard Index		
	P	*F*	*S*		*P*	*F*	*S*
N01	1.61	0.82	6.44	N14	2.65	0.59	0.80
N07	1.44	1.53	0.79	N15	1.08	2.35	0.69
N02	1.32	1.34	0.46	N16	1.55	1.27	1.23
N03	1.43	1.07	0.79	N17	1.52	1.27	0.67
N04	1.51	1.28	2.98	N18	1.64	1.14	1.07
N05	1.28	1.43	0.82	N19	1.54	1.10	1.76
N06	1.78	1.54	0.73	N20	1.00	1.25	0.68
N08	1.11	1.55	0.33	N21	1.94	1.02	1.43
N09	0.99	2.01	0.27	N22	3.37	1.36	1.18
N10	1.87	1.44	0.89	N23	2.81	1.03	1.98
N11	1.72	1.13	1.36	N24	2.45	0.99	1.37
N12	0.99	2.47	0.89	N25	2.86	1.01	1.98
N13	1.92	1.61	1.06				

The distribution of standard indexes of phosphorus, fluorine and sulfur was shown in Figure 4. According to the calculation of MAPGIS software, the area of sediments suffered phosphorus pollution took up 99.1%

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in the whole lake, and the areas where standard indexes exceeded 2 took up 26.4%. The area suffered fluorine pollution took up 93.4%, and the areas with the standard indexes exceeding 2 took up 6.7%. The sulfur polluted area took up 52.8% in the whole lake, and the area with standard indexes exceeding 2 took up 4.1%.

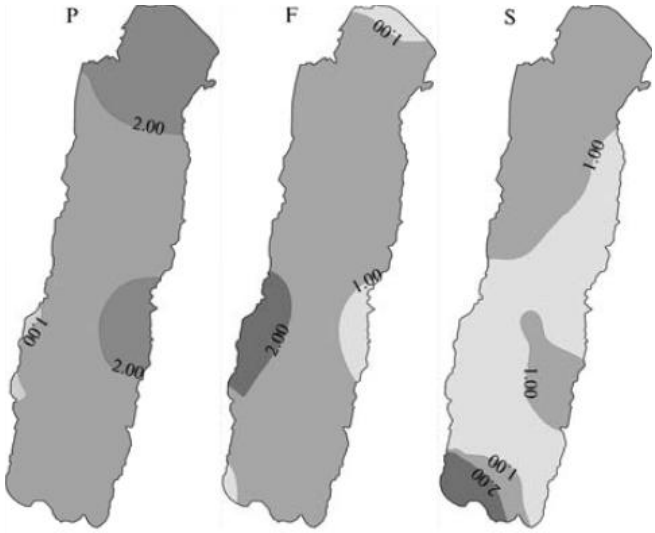

Figure 4 : Isograms of the standard index of contaminants in sediments

The distribution of standard indexes of phosphorus, fluorine and sulfur was shown in Figure 4. According to the calculation of MAPGIS software, the area of sediments suffered phosphorus pollution took up 99.1% in the whole lake, and the areas where standard indexes exceeded 2 took up 26.4%. The area suffered fluorine pollution took up 93.4%, and the areas with the standard indexes exceeding 2 took up 6.7%. The sulfur polluted area took up 52.8% in the whole lake, and the area with standard indexes exceeding 2 took up 4.1%.

CONCLUSION

The average contents of total phosphorus, fluorine and sulfur in the surface sediments in the Yangzonghai Lake were 1041.3, 1074.8 and 2743.1mg/kg respectively, and the spatial distribution showed obvious pollution patterns. The accumulation of these three pollutants was closely related to the economic development and the waste discharging of the surrounding area. The Discharge of domestic sewage, industrial wastewater, industrial waste gas as well as motor vessels, cage fish culturing and other human activities were the main sources of phosphorus, fluorine and sulfur in the surface sediments of the Yangzonghai Lake.

The environmental quality of the Yangzonghai Lake was seriously affected by the accumulation of phosphorus, fluorine and sulfur in the sediments with the average values of the single standard indexes of 1.74, 1.34 and 1.31 respectively. The pollution range of phosphorus covered nearly the entire Yangzonghai Lake, and the average pollution degree was the highest. The pollution range of fluorine was relatively wide with the standard indexes mainly centralized between 1 and 2. The pollution range of sulfur took about a half of the entire lake. Except for the extremely serious pollution in small ranges along the southern shore, the pollution degree of sulfur in other areas was slightly lower than those of phosphorus and fluorine.

On suitable conditions, such as temperature, dissolved oxygen and pH, the phosphorus, fluorine and sulfur accumulated in the sediments of the Yangzonghai Lake could be released into the overlying water, and there were potential environmental risks. Therefore, controlling pollution sources in highly polluted areas and treating the sediments needed to be implemented urgently.

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REFERENCES

[1] X.H.Bai, W.D.Yang and H.L.Chen; Influence of sediment in city river on water pollution restoration, Acta Scientiae Circumstantiae, **22**, 562–565, **(2002)**.

[2] L.F.Li, X.B.Zeng, G.X.Li; Heavy metal pollution of Wenyu River sediment and its risk assessment, Acta Scientiae Circumstantiae, **27**, 289–297, **(2007)**.

[3] Q.W.Yang, C.Y.Lan, W.S.Shu; Investigation on Heavy Metal Pollution in the Surface Sediments on Lechang Section of Wujiang River, The Administration and Technique of Environmental Monitor-

ing, **20**, 18–21, **(2008)**.

[4] J.S.Chen; Some Problems in research of metal contamination of sediment, Techniques and Equipment for Environmental Pollution Control, **4**, 1–2, **(1983)**.

[5] H.R.Ma, J.H.Ren, J.F.Ji; Distribution and enrichment of heavy metal in sediments and soils in Nanjing section of the Yangtze River, The Administration and Technique of Environmental Monitoring, **22**, 32–36, **(2010)**.

[6] M.W.Feng, Y.H.Wu, C.S.Gong; Distribution of phosphorus speciation in Lake Xuanwu sediments, The Administration and Technique of Environmental Monitoring, **19**, 19–22, **(2007)**.

[7] X.F.Wang; Actuality investigation and prevention measures on fluorine pollution of soil in some aluminium factory area, Gansu Metallurgy, **30**, 62–65 **(2008)**.

[8] S.S.Luo, G.J.Wan; The study of sulfur geochemical cycle mechanisms in lake sediments, Sichuan Environment, **19**, 1–3 **(2000)**.

[9] Z.Y.Li, Y.Sun; Brief Discussions on Controlling Measures and Water Body Characteristics of Yangzonghai Lake, Yunnan Environmental Science, **24**, 108–111, **(2005)**.

[10] H.M.Wang; Present Situation and Trend Analysis of Water Quality in Yangzonghai Lake, Yunnan Environmental Science, **22**, 170–171 **(2003)**.

[11] Environmental Monitoring of China; Soil Element Background Values of China, Beijing: China Environmental Science Press, **(1990)**.

[12] H.N.Lin, J.Y.Fu and H.Wu; Distribution and influential factors of sulfur in mangrove wetlands in China, Marine Sciences, **33**, 79–82 **(2009)**.

[13] C.L.Yang, J.Z.Chen, B.He, Origin analysis of overproof of total phosphorus and its environmental capacity in Yangzonghai Lake, Environmental Science Survey, **27**,.44–46 **(2008)**.

[14] L.Yang, J.Sun; Phosphorus pollution investigation of Wuli Lake and Meiliang Lake, The Administration and Technique of Environmental Monitoring, **13**, 18–20 **(2001)**.

[15] X.F.Wang; Actuality investigation and prevention measures on fluorine pollution of soil in some aluminium factory area, Gansu Metallurgy, **30**, 62–65 **(2008)**.

[16] Q.H.Cai, Q.Du, Z.B.Lu; Distribution of sulphide in sediments from main bays in Fujian, Journal of Oceanography in Taiwan Strait; **23**, 24–32 **(2004)**.

[17] X.P.Huang, F.Guo, L.M.Huang; Distribution characteristics and pollution of nitrogen and phosphorus in core sediments of marine culture area in Dapeng Cove, Journal of Tropical Oceanography, **29**, 91–97 **(2010)**.

[18] J.Li, Z.M.Xie, J.M.Xu; Preliminary study on guideline on soil health quality index of fluorine and method of its evaluation in China, Journal of Zhejiang University (Agriculture & Life Sciences), **31**, 593–597 **(2005)**.