Acta Technica *62* (2017), No. 3B, 739–746

Occurrence forms and distribution characteristics of phosphorus in different grain size sediments in yao lake

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Abstract. Through cluster analysis methodand the selection of points, this paper analyzes the distribution of the mass fraction of different size fractions of sediments from the lake,studiesthe occurrence forms and distribution characteristics of phosphorus in different grain size sediments,and investigates the distribution of phosphorus in different grain size sediments. The results show that: (1) the mass fraction of different particle size in the sediment size is: coarse sand A<fine sand B< silt clay C,of which siltclay C is the main one, and the average mass fraction is 74%; (2)the phosphorus content of phosphorus fractions in different grain size sediments is Fe/Al-P>OP,among them, the maximum proportion of Fe/Al-P to TP is 66.71%, and the minimum is 39.56%;(3) the content of TP, Fe/Al-P and OP in the sediments of the same position and different grain size has the same trend. In a certain size range, with the grain size decreases, the content of the three increased, when the particle size is less than 0.063mm, the content of the three were decreased, and B>A>C;the contents of TP, Fe/Al-P and OP in the sediments with different particle size and same particle size were significantly different;(4) the sediment particle composition has a great effect on the distribution of phosphorus forms in different grain size sediments,different forms of phosphorus in sediments, TP, Fe/Al-P and OP are mainly distributed in the C grain size;the proportion of different phosphorus forms in the sediments of different particle size fractions (Mi value) is C>B>A, and the proportion of three forms of phosphorus in the C grain size sediments is 70%.The results of this study provide data and theoretical support forcirculation mechanism and eutrophication mechanism ofsediment-phosphorus inYao Lake.

Key words. Yao Lake, grain size, sediment, phosphorus occurrence pattern, distribution characteristics.

[1]Acknowledgment - This research is supported by the foundation of National Water Pollution Control and Management Science and Technology Major Special Projects (granted by 2009ZX07106-001).

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1. Introduction

Phosphorus, a major nutrient in aquatic organisms, is a major limiting factor for lake eutrophication[1−2].The occurrence form and content of phosphorus in lake sediments have different effects on eutrophication of water body, and simultaneously determine the amount of bioavailable phosphorus in sediment that can be exchanged at the interface[3−4].The grain size composition is one of the important characteristics of lake sediments,the sediments of different grain size have different specific surface area and quality,and there were differences in the occurrence characteristics of phosphorus and the exchange effects of phosphorus on the solid-liquid interface[5−7].Therefore, it is important to study the occurrence forms and distribution characteristics of phosphorus in different grain size sediments for revealing the mechanism of phosphorus cycling in Lake Ecosystems.

Yao Lake (116°01' 116°05' E 28°38' 28°44' N), located in the eastern suburbs of Jiangxi City, Nanchang Province, the middle and lower reaches of the Yangtze River, and it is a closed city shallow lake with aquaculture and water recreation.The lake is rectangular, with a total area of about 15.86km^2, an average water depth of 2m[8].The eutrophication process of the water body is becoming more and more serious, and gradually transformed from the nutrient type to the eutrophication type. It has been in the initial stage of eutrophication[9].

In this paper, the sampling points of Yao Lake are classified by cluster analysis,and the point of the study is selected.Based on this, this paper analyzes the distribution of the mass fraction of different size fractions of sediments from the lake, studies the occurrence forms and distribution characteristics of phosphorus in different grain size sediments, and investigates the distribution of phosphorus in different grain size sediments. The results of this study provide data and theoretical support forcirculation mechanism and eutrophication mechanism ofsediment-phosphorus in-Yao Lake.

2. Materials and methods

2.1. Sample collection and pretreatment

The distribution of sediment sampling is shown in figure 1. The surface sediment samples of 10cm were collected by a simple cylindrical sampler. The samples were packed in sealed plastic bags, stored in ice boxes and transported to the laboratory. Gently crush the sample with a glass rod, and each sediment sample is divided into 3 different size fractions after 1mm, 0.25mm, and 0.063mm screening.They are coarse sand grade (>0.25mm), fine sand grade (0.063∼0.25mm) and silty sand clay particle size (<0.063mm) (above 3 particle size are expressed by A, B and C)[11].Samples of each particle size are separately packed and sealed.

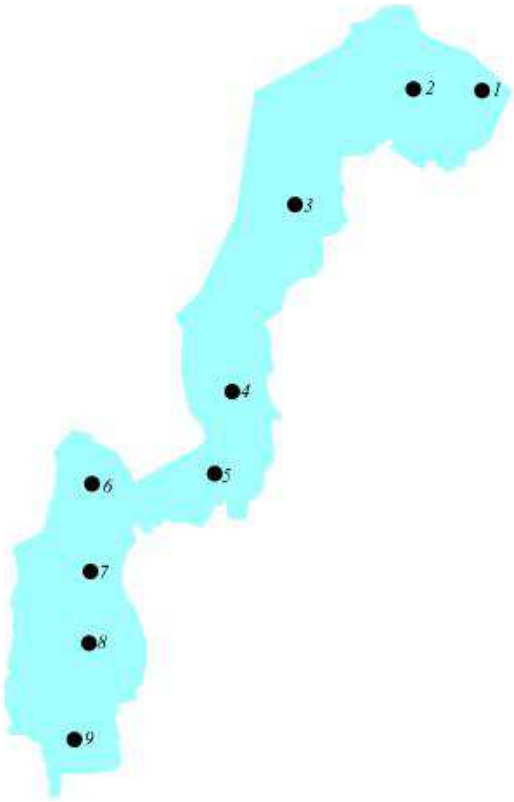

Fig. 1. Distribution of sediment sampling site in Yao Lake

2.2. Analysis method

Determination of phosphorus fractions in grain size fractions of sedimentsuses the SMT separation method developed under the framework of the European standards testing Committee[10].The indicators for the analysis included total phosphorus (TP), organic phosphorus (OP), iron and aluminum bound phosphorus (Fe/Al-P). The content of phosphorus in the extract was determined by molybdenum antimony spectrophotometric method.

2.3. Research methods

(1)Cluster analysis

Clustering analysis is an important data processing method in statistics. The purpose of clustering analysis is to find the natural grouping in data set[11].Taking the grain size of sediment as the classification object, this paper uses the Q cluster analysis method to get the monitoring data with higher similarity of different particle size,and show that the same kind of monitoring has the characteristics and structure of[10].

(2)Data processing
PASW, Statistics18 and Excel2007 software are used to analyze the data.

3. Results and discussion

3.1. The confirmation of the study sites and the selection of phosphorus speciation index

(1)The confirmation of the study sites
By using the method of cluster analysis, taking the grain mass fraction of sediment as a variable, taking the Euclidean distance as the metric, using the nearest neighbor element, the Q cluster analysis of 9 sampling points in the lake district was carried out.The dendrogram of cluster analysis of sampling site is shown in figure 2. From Figure 2 we can see when the distance coefficient is equal to 10, 9 samples can be divided into 3 types.Class I is 3, 6, 7, and 8, class II is 1, 2, 4, and 5, and class III is 9. In order to simplify the research work, we selected 6 in class I, 2 in class II, 9 in class III for the study.

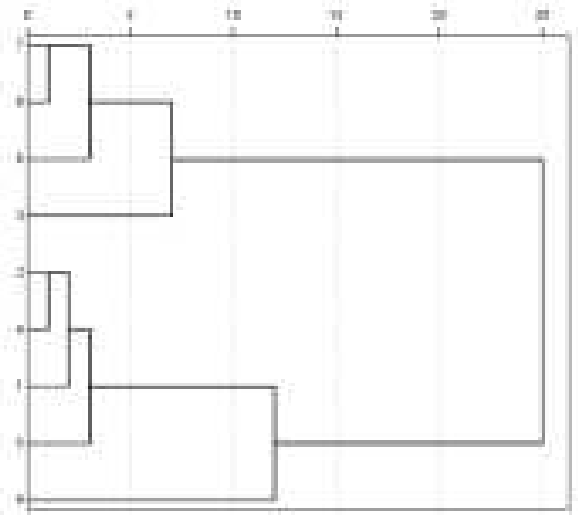

Fig. 2. Dendrogram of cluster analysis of sampling site

(2)Selection of phosphorus speciation index
Literature[4] studies show that the phosphorus speciation in the sediments of Yao Lake is mainly inorganic phosphorus Fe/Al-P, and the content of Ca-P is relatively stable in different sediments. Therefore, we selected the phosphorus forms of TP, Fe/Al-P and OP to do relevant research.

3.2. Descriptive statistics of grain size composition in sediments

Descriptive statistics for sediment quality fractions at different grain sizes are shown in table 1. Table 1 shows that mass fraction of each particle in the sedimentin ascending order of size is A<B<C,the order of magnitude of its standard deviationσ is A<B<C,and the$\sigma_B$is 2.5 times that of σ_A, σ_C is 3.5 times that of σ_A.This shows that the particle size fraction of A is more evenly distributed in the lake region, while the B particle size and C particle size fraction in the lake region vary greatly.From the above analysis, it can be concluded that the grain size of the sediments in the lake region is dominated by C particle size, that is, silt and clay particles(the average mass fraction is 73.87%).and the distribution of C particle size in the lake district is obviously different.

Table 1. Descriptive statistics for sediment quality fractions at different grain sizes(n=9)

Grain distinction composition/mm	Minimum value(%)	Maximum value(%)	Average value(%)	Standard deviation(%)
A	2.84	9.61	6.36	2.50
B	11.52	27.35	19.77	6.47
C	63.54	85.64	73.87	8.88

3.3. The occurrence forms and distribution characteristics of phosphorus in different grain size sediments

The distribution of phosphorus content in different grain size sediments is shown in figure 3.The mass fraction of A, Fe/Al-P and OP in the sediments to TP (average value) is41.55%∼66.71% (53.06%) and 25.96%∼45.14% (35.39%); the B particles are 39.56∼62.67% (50.29%) and 22.25%∼48.42% (36.69%), C particles are 41.84%∼52.97% (48.98%) and 28.34%∼47.50% (35.43%).Thus it can be concluded that the weight ratio of total phosphorus to total phosphorus in different grain size sediments is Fe/Al-P>OP, which is consistent with the results of shallow lakes in the middle and lower reaches of the Yangtze River.

It can be seen from Figure 3: first,it can be seen from Figure 3: first, the same content of TP, Fe/Al-P and OP points in different grain size sediment from the three have the same change trend, and B>A>C, which indicates that in a certain size range, when the sediment size becomes finer, the three content of TP, Fe/Al-P and OP increase gradually, when sediment particle size decreases to 0.063mm, when the particle size becomes finer, the content decreased,the results of this study are inconsistent with the conclusions in the literature [3], that is,as the grain size of sediment is reduced from coarse to fine, the content of three increases gradually.The causes of this phenomenon may be related to the source and the environmental

conditions of the sediments; second, the content of different points of the same size sediments in TP, Fe/Al-P and OP have great differences,the highest values of the three contents appeared at 6 site, and their lowest values appeared at 2 site.This is mainly due to the pollution level caused by the surrounding pollution sources. There are more pollution sources such as ammonia plants, universities and aquaculture bases around the 6 points, but there is less pollution around the 2 site.

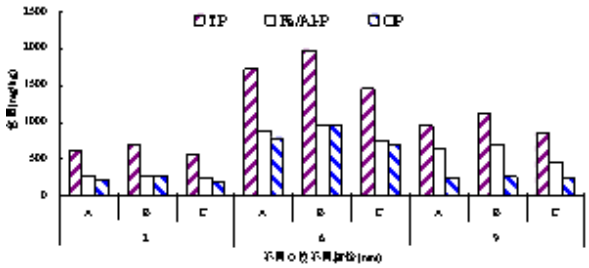

Fig. 3. Distribution of phosphorus forms contents in different grain size sediments

3.4. Correlation between grain size composition and phosphorus content in sediments

Pearson correlation analysis was used to study the correlation between grain size composition and phosphorus content in sediments, so as to better understand the distribution characteristics of phosphorus fractions in sediments of different grain size. The correlation coefficient γbetween grain size composition and phosphorus content in sediments is shown in table 2. From table 2 we can see: on the one hand, A, B grade and different forms of phosphorus were negatively correlated, C grade and different forms of phosphorus were positively correlated, indicating that the sediment particle size composition has a great influence on the distribution of phosphorus forms in different grain size sediments, and different phosphorus forms are mainly accumulated in the C particle size.On the other hand, A, B grade and Fe/Al-P were related in the level of=0.05, the correlation coefficient γ were -0.867 and -0.784; C grade and Fe/Al-P were related in the level of=0.01, the correlation coefficient γ were -0.886, and $\gamma_A<\gamma_B<\gamma_C$. The mass fraction between each particle size is A<B<C.This indicates that the grain size and grain size fraction of sediments have a great influence on the main forms Fe/Al-P distribution of phosphorus. In the Yao Lake, phosphorus forms Fe/Al-P preferentially combines fine particles. This result is consistent with the results of Han Lu[5,14−15].

Table 2. The correlation coefficient γ between grain size composition and phosphorus content in sediments n=9

Phosphorus speciation mg/kg	Particle size fraction %		
	A	B	C
TP	-0.696**	-0.802***	0.577*
Fe/Al-P	-0.867**	-0.784**	0.886***
OP	-0.511	-0.735**	0.375

Note: * related at 0.1 level (bilateral); * * significantly related at 0.05 level (bilateral); * * * much significantlyrelated at 0.01 level (bilateral).

3.5. The distribution of phosphorus in different grain size sediments

According to the calculation method of Mi index in 1.3 (2), the proportion of phosphorus in sediments of different sites and different grain sizes is shown in figure 4. We can see from Figure 4:The proportion of different phosphorus fractions in sediments of different particle size in the same position(Mi value) was C>B>A, which means that when the grain size of sediment decreases and the Mi value increases gradually, the contribution of phosphorus form to the same phosphorus content in the same sediment will also increase; and you can also see from Figure 4 that The maximum proportion Mi of different phosphorus forms in the sediments of different particle size and same particle size is C particle size,average values of TP, Fe/Al-P and OP Mi were 70%, 69.27% and 69.59%,that is to say, the proportion of three forms of phosphorus in C grain sediments beyond 70%.When the grain size is <0.063mm, the grain size isfine particle[16].In combination with the analysis of the 2.4 section,this further indicates thatthe different forms of phosphorusTP??Fe/Al-P and OP in the sediments of Yao Lake are mainly distributed in fine grain.

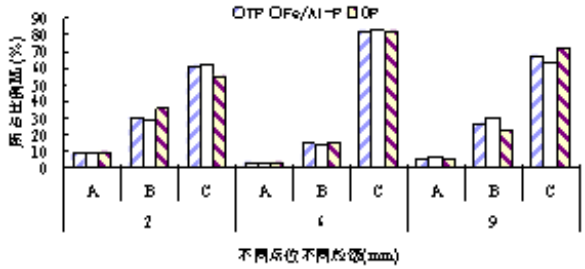

Fig. 4. The proportion of phosphorus in different point size and different grain fraction sediments

4. Conclusion

(1) The distribution of mass fractions in different fractions of sediments in Yao Lake is coarse sandA< fine sand B<silt clay C.The main content is silt clay C, and the average of mass fraction is 74%;

(2) The weight ratio of phosphorus speciation to total phosphorus in different grain size sediments in Yao Lake is Fe/Al-P>OP;

(3) The contents of phosphorus forms TP, Fe/Al-P and OP in the sediments of the same position and different particle sizes all have the same trend of variation, and B>A>C,and the contents of three of the sediments with different particle size and same particle size have great difference;

(4) In Yao Lake, sediment particle composition has a great effect on the distribution of phosphorus forms in different grain size sediments,different forms of phosphorus TP, Fe/Al-P and OP in sediments are mainly distributed in the C grain size;the proportions(Mi) of different phosphorus forms in the sediments of different particle sizes were C>B>A.

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Received November 16, 2017