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Assessment of heavy metal enrichment and its human impact in lacustrine sediments from four lakes in the mid-low reaches of the Yangtze River, China

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Abstract
Sediments from four lakes in the mid-low reaches of the Yangtze River, Taibai Lake, Longgan Lake, Chaohu Lake and Xijiu Lake, were chosen to evaluate their enrichment state and history. The state of heavy metal enrichment was at a low level in the sediment of Taibai Lake and Longgan Lake. The enrichment state of Co, Cr and Ni was also low in the sediment of Chaohu Lake and Xijiu Lake, while Cu, Pb and Zn enrichment reached a higher level. Mass accumulation fluxes were calculated to quantitatively evaluate the anthropogenic contribution to heavy metals in the sediment. The anthropogenic accumulation fluxes were lower in the sediment of Taibai Lake and Longgan Lake compared with the other two lakes, where heavy metals, especially Cu, Pb and Zn, were mainly from anthropogenic sources. Heavy metal accumulation did not vary greatly in the sediment of Taibai Lake and Longgan Lake, while that in Chaohu Lake and Xijiu Lake increased since the 1950s and substantially increased since the 1980s, although a decrease occurred since 2000 AD in Xijiu Lake. Heavy metal enrichment was strongly related to human activities in the catchment. The development of urbanization and industrialization was much more rapid in the catchments of Chaohu Lake and Xijiu Lake than of the other two lakes, and thus large amounts of anthropogenically sourced heavy metals were discharged into the lakes, which resulted in a higher contamination risk. However, human activities in the Longgan Lake and Taibai Lake catchments mainly involved agriculture, which contributed a relatively small portion of heavy metals to the lakes.

Key words: heavy metals; human activity; accumulation flux; lake sediment
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Introduction
Human activities play a key role in heavy metal accumulation in lake sediment. How to evaluate the state of heavy metal contamination in lacustrine sediments and how to distinguish the anthropogenic contribution of heavy metals from natural background levels are key issues at present. In recent years, several approaches have been developed including the index of geoaccumulation (Igeo), enrichment factor (EF), sediment quality guidelines, the potential ecological risk index, the pollution load index, and so on. Igeo and EF have been generally used to evaluate the contamination level of heavy metals (Loska et al., 1997; Soto-Jiménez and Páez-Osuna, 2001; Loska and Wiechula, 2003; Soto-Jiménez et al., 2003; Tylmann, 2005; Acevedo-Figueroa et al., 2006; Wu et al., 2007; Jara-Martín et al., 2008; Amin et al., 2009), by comparing the concentrations of heavy metals with their background levels; meanwhile, they have also been used to reflect the anthropogenic impact (Mil-Homens et al., 2009; Zhang et al., 2009). These sediment quality guidelines have been widely used in the United States, Canada and North Europe to evaluate the sediment quality (Wang et al., 2001; Pekey et al., 2004). The potential ecological risk index proposed by Hakanson (1980) is usually used to evaluate the potential risk of heavy metals in the sediment (Liu et al., 2002; Yang et al., 2003; Ma and Wang, 2003).

The flux of an element has been proved to be a more effective way than the concentration to evaluate the element accumulation in the sediment (Liu et al., 2007a; Wu et al., 2008). The flux, calculated based on the element concentration and the mass accumulation rate, represents the inputs of dry material mass, and thus to a large extent
reflects the impact of natural and anthropogenic factors on the element accumulation in the sediment.

The Yangtze River is the largest river in the Euro-Asian continent, and there are many lakes distributed along its mid-low reaches. With the rapid development of the economy in this area, many lakes have suffered from serious heavy metal contamination, which has attracted the attention of many researchers (Fan et al., 2002; Rose et al., 2004; Qiao et al., 2005; Wu et al., 2007; Yao et al., 2008). The temporal and spatial distribution characteristics of heavy metals in lake sediment have been widely investigated, and some studies on the anthropogenic inputs of heavy metals have also been conducted using different methods. All of these works demonstrated that the contamination of heavy metals in the lakes along the mid-low reaches of the Yangtze River was accelerated by human activities, although the contamination state was different for each lake. However, there have been few studies concerning the quantitative identification of anthropogenic contributions to these lakes.

Four lakes were selected in this research due to the differences in types and intensity of anthropogenic activities in their catchments. Taibai Lake is located in Huangmei County, eastern Hubei Province, China. Its area was about 69.2 km² before the 1950s, but shrank to its present size of 25.1 km² due to reclamation projects since the early 1950s. Taibai Lake collects water from the Jingzhu River and Kaotian River to the north, and discharges into Longgan Lake and finally into the Yangtze River. Chaohu Lake, one of the five largest freshwater lakes in China, is located in the central part of Anhui Province. The ecological environment in the lake catchment has been seriously deteriorated by human activities. For instance, the industrial and agricultural sewage entering the lake was $1.5 \times 10^8$ tons in 1985 AD, and Hefei City and Chaohu City contributed $1.1 \times 10^8$ tons and $0.3 \times 10^8$ tons respectively to the lake. It is a typical eutrophic lake at present (Wang and Dou, 1998). The other two lakes are Longgan Lake and Xijiu Lake, which have been introduced by Wu et al. (2010a, 2010b) and Bing et al. (2011) in earlier work. The objectives of this research are to compare the enrichment state and history of heavy metals in the mid-low reaches of the Yangtze River.

1 Materials and methods

1.1 Sample collection

Sediment cores were taken from Taibai Lake (29°59'40.8"N, 115°48'26.1"E, 2007), Longgan Lake (29°57'37.7"N, 116°12'42.5"E, 2008), Chaohu Lake (31°33'05.7"N, 117°23'11.9"E, 2007) and Xijiu Lake (31°23'48.8"N, 119°43'33.8"E, 2004) using a gravity corer (Fig. 1). The sampling sites were selected in the open area of the lakes to avoid direct human disturbance. The outermost sediment that was in contact with the
walls of the core barrel was discarded. The sediment profiles were sectioned with an interval of 1 cm, and the sectioned samples were sealed and kept frozen for further processing.

1.2 Geochronology and mass accumulation rates
All the cores were dated using $^{210}\text{Pb}$, $^{137}\text{Cs}$ and the sediment characteristics. $^{137}\text{Cs}$, $^{210}\text{Pb}$ and $^{226}\text{Ra}$ activities were detected using an Ortec HPGe GWL series well-type coaxial low background intrinsic germanium detector after samples were dried at low temperature ($< 40^\circ\text{C}$) and weighed. The excess $^{210}\text{Pb}$ ($^{210}\text{Pb}_{\text{exc}}$) was obtained by subtracting the activity of $^{226}\text{Ra}$ from the total activity of $^{210}\text{Pb}$ ($^{210}\text{Pb}_{\text{tot}}$). Then $^{210}\text{Pb}_{\text{exc}}$ was used to develop a chronology using the constant rate of supply (CRS) dating model (Appleby and Oldfield, 1978). The geochronology in the sediments of Taibai Lake and Chaohu Lake has been discussed in detail by Liu et al. (2009), and the dating results in the sediments of Longgan Lake and Xijiu Lake calculated by Wu et al. (2008, 2010a) were cited in this research. Based on their results, the mass accumulation rates (MARs) in the four cores are summarized in Fig. 2.

1.3 Grain-size analysis
About 5 g sample was placed in a beaker which was rinsed beforehand; 5% HCl was added to remove the carbonate, and 5% NaOH to remove organic matter, then the sample was washed to neutral. The residues were dispersed with an ultrasonic oscillator for 15 min after mixing with a dispersant solution (Na$_2$PO$_4$). The grain size was determined using a Mastersizer 2000 Laser Grain-size Meter.

1.4 Element analysis
Aliquots of samples were digested with nitric acid, hydrofluoric acid and perchloric acid. After the digestion, the element (Al, Co, Cr, Cu, Ni, Pb and Zn) concentrations were determined by Inductively Coupled Plasma-Atomic Emission Spectrometry with a SPEX$^\text{TM}$ standard solution from the US as the standard. The uncertainty of the SPEX$^\text{TM}$ standard solution was 2%. Quality control was assured by the analysis of duplicate samples, blanks and reference materials (GSD-9 and GSD-11, Chinese geological reference materials). Measurement errors were less than 10%.

1.5 Calculation of enrichment factors
Enrichment factors (EFs) of heavy metals were calculated by Eq. (1) (Soto-Jíménez and Paez-Osuna, 2001):

$$\text{EFs} = \frac{(\text{Me})_{\text{S}}}{(\text{Me})_{\text{B}}}$$

where, $(\text{Me})_{\text{S}}$ was the ratio of metal concentrations measured to Al in the sediment, and $(\text{Me})_{\text{B}}$ was the corresponding ratio in the Chinese crust.

2 Results

2.1 Grain-size distribution in the sediment
The grain size, expressed as the size of median particles ($d(0.5)$, Fig. 3), showed that $d(0.5)$ in the core of Taibai Lake ranged between 4.3% and 7.1% with mean value of 5.4%, and there was a gradual decreasing trend with time. In the core of Longgan Lake, $d(0.5)$ varied between 6.2% and 15.5% with mean value of 9.2%. Temporally, large variations occurred before 1930 AD, and then little variation was seen. In the core of Chaohu Lake, $d(0.5)$ ranged between 6.1% and 10.1% with mean value of 7.6%, and in the core of Xijiu Lake it ranged between 15.5% and 29.2% with mean value of 20.2%. Generally, the temporal variation of $d(0.5)$ did not show any marked trend in the cores of Chaohu Lake and Xijiu Lake. One way ANOVA analysis ($p < 0.05$) showed that the grain size in the four cores was significantly different with the order: Xijiu Lake > Longgan Lake > Chaohu Lake > Taibai Lake.

2.2 Heavy metal concentrations in the sediment
Although the four lakes are located in the mid-low reaches of the Yangtze River, the marked differences were observed in the heavy metal concentrations in the sediments (Table 1). In general, except for Cu concentrations, which were highest in the core of Xijiu Lake since the 1950s, concentrations of Co, Cr, Cu and Ni were higher in the cores of Longgan Lake and Taibai Lake than in the cores.

![Fig. 2](image-url) Mass accumulation rates (MARs) in the four lake sediments cited from Liu et al. (2009) and Wu et al. (2008, 2010a).
Table 1  Heavy metal concentrations in the four lake sediment (unit: mg/kg)

<table>
<thead>
<tr>
<th>Values in Chinese crusta</th>
<th>Taibai Lake</th>
<th>Longgan Lake</th>
<th>Chaohu Lake</th>
<th>Xijiu Lake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prior to 1930s</td>
<td>Since 1930s</td>
<td>Prior to 1930s</td>
<td>Since 1930s</td>
</tr>
<tr>
<td>Co</td>
<td>32</td>
<td>19.0</td>
<td>16.0</td>
<td>16.4</td>
</tr>
<tr>
<td>Cr</td>
<td>63</td>
<td>100.1</td>
<td>103.0</td>
<td>106.5</td>
</tr>
<tr>
<td>Cu</td>
<td>38</td>
<td>28.2</td>
<td>44.2</td>
<td>20.4</td>
</tr>
<tr>
<td>Ni</td>
<td>57</td>
<td>41.0</td>
<td>36.7</td>
<td>39.9</td>
</tr>
<tr>
<td>Pb</td>
<td>15</td>
<td>42.1</td>
<td>38.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Zn</td>
<td>86</td>
<td>68.2</td>
<td>87.5</td>
<td>100.2</td>
</tr>
</tbody>
</table>

Data are expressed as mean values.

a Institute of Geochemistry Chinese Academy of Sciences, 1998.

of Chaohu Lake and Xijiu Lake. Pb and Zn concentrations displayed the highest value in the core of Xijiu Lake followed by Chaohu Lake and then Longgan Lake and Taibai Lake. Some other studies also reported that clear

Fig. 3  Vertical profiles of grain size (d(0.5)) and heavy metal concentrations with time in the lake sediments.
differences in heavy metal concentrations existed in the lake sediments along the mid-low reaches of the Yangtze River (Yuan et al., 2002; Jin et al., 2010; Wei et al., 2010). These differences might be related to the local geochemical background as well as the type and intensity of human activities in the catchment.

The vertical distribution of heavy metal concentrations showed that in the cores of Taibai Lake and Chaohu Lake, the concentrations increased from bottom upward, and peaked in the upper layers of the cores (Fig. 3). The concentrations of heavy metals were lower in the bottom layers of the core of Longgan Lake (prior to the 1950s), but thereafter abruptly increased and continued to increase with variation in the surface layers. In the core of Xijiu Lake, the concentrations increased gradually from the bottom, reached their peak values in the mid-layers with some variation (between 1950 AD and 2000 AD), and then decreased in the upper layers.

### 2.3 Enrichment factors

As shown in Fig. 4, the EF values in the core of Taibai Lake were lower than 1.0 for Co, Cu, Ni and Zn, between 1.3 and 1.7 with mean value of 1.4 for Cr, while the values for Pb varied between 2.3 and 3.1 with mean value of 2.6. The EF values in the core of Longgan Lake were lower than 1.0 for Co and Ni, between 0.9 and 1.3 with mean value of 1.1 for
Cu and Zn, between 1.3 and 1.9 with mean value of 1.6 for Cr and between 2.2 and 3.1 with mean value of 2.5 for Pb. In the core of Chaohu Lake, Pb had the largest mean EF value with the highest value of 4.2, followed by Cr and Zn. The rest of the metals had EF values lower than 1.0. The heavy metals with mean EF values above 4.0 were Pb and Zn, which peaked at 6.9 and 10.3 respectively in the core of Xijiu Lake, while the values of Cu were between 0.7 and 4.1 with mean value of 1.8. The EF level of Cr was between 1.0 and 1.8 with mean value of 1.3, and the rest of the metals had EF values lower than 1.0, especially Co which had the lowest value, lower than 0.5.

Temporally, there was no clear enrichment variation for the cores of Taibai Lake and Longgan Lake. However, in the core of Chaohu Lake, the enrichment level of heavy metals was relatively low prior to the 1980s, but thereafter the enrichment level increased substantially, and the increase continued to the present. There was no marked variation of Co enrichment in the core of Xijiu Lake. The other heavy metal enrichments increased slowly prior to the 1930s, and clearly increased thereafter, especially for Pb and Zn. Since the 1950s, all heavy metal enrichment greatly increased with little variation, and peaked in the 1990s, but decreased since 2000 AD.

3 Discussion

3.1 Enrichment state of heavy metals in the four lakes

Compared with concentrations, EFs calculated by Al standardization, which are able to eliminate the grain-size effect on element concentrations, can effectively indicate the enrichment or contamination state of heavy metals in sediment (Loska et al., 1997; Soto-Jiménez and Páez-Osuna, 2001; Amin et al., 2009). The enrichment level of Co, Cr and Ni was relatively low in the four lakes, especially Co in the sediment of Xijiu Lake, which exhibited a large depletion in the sediment. Cu enrichment in Taibai Lake, Longgan Lake and Chaohu Lake was also at a low level, while its level in the Xijiu Lake showed a large depletion in the sediment. Cu enrichment in Taibai Lake, Longgan Lake and Chaohu Lake was generally the same, which reflected their similar sources of heavy metals in the past 100 years. There was marked fluctuation for EFs prior to the 1930s in Chaohu Lake, which was due to the frequent fluctuations in hydrodynamic conditions indicated by the grain size and MARs (Figs. 2 and 3). The enrichment varied slightly between the 1930s and 1950s, and thereafter a marked increase occurred. It was not until the 1980s that a substantial increase of heavy metal enrichment occurred in the lake. In Xijiu Lake, Co had no clear enrichment in the whole profile, while the enrichment level of other metals showed that there was relatively low enrichment prior to the 1930s, substantial increase occurred between the 1930s and 1950s, and thereafter the increase became more marked. The heavy metal enrichment reached its peak level between 1990 AD and 2000 AD, and then a clear decrease occurred.

Heavy metals entered the lakes along the mid-low reaches of Yangtze River by two major routes: (1) point source (industrial and municipal) discharges; and (2) diffuse inputs, such as urban and agricultural runoff and direct atmospheric deposition. For Chaohu Lake, with a large catchment, direct atmospheric deposition to the lake surface has been less important than point and non-point source inputs from the catchment. During the early half of the 20th century and the 1950s, the enrichment of heavy metals in the sediment was at a relative low level due to the limited development of the economy. Rapid modern urbanization and industrialization started with the 1980s within the lake catchment. For instance, there were about 50,000 people in Hefei City in the 1950s; however, the number increased to more than 800,000 in the early 1980s. Similarly, the enterprises and mining operations reached more than 2500 in 1985 AD (Codification Committee of Chaohu Record, 1989). The increase of population and industries led to a great number of heavy metals being discharged into the lake as a result, which was clearly demonstrated by the concentrations and contamination indexes of Cu, Pb and Zn. In recent years, the development of industrialization and urbanization has been accelerated in the catchment of Chaohu Lake, which deteriorated the
water quality considerably, although many remediation projects and efforts have been implemented. The enrichment state of Cu, Pb and Zn in the sediment confirmed the serious conditions at present.

Point and non-point source inputs from the catchment were also the major source of heavy metals in Xijiu Lake; however, the record of atmospheric deposition could be also found in the sediment. For instance, the enrichment history of Pb and Zn was earlier than that of other metals in the sediment (Figs. 3 and 4). Sun et al. (2009) and Wu et al. (2010b) have discussed the enrichment history and sources of heavy metals in the Xijiu Lake sediment using different methods. Their results also revealed a very substantial human contribution to heavy metals in the sediment.

The enrichment state of heavy metals in the sediment of Taibai Lake and Longgan Lake was lower than that of Chaohu Lake and Xijiu Lake. Agricultural production was the main human activity in the catchments of Taibai Lake and Longgan Lake, and the major event affecting the lake environment was the reclamation during the 1950s and 1960s (Wang and Dou, 1998; Wu et al., 2010a), which reduced the lake area and caused a lot of detrital materials to enter the lakes. However, the agro-activities in the catchments of Taibai Lake and Longgan Lake contributed a smaller amount of heavy metals to the sediment compared with that of Chaohu Lake and Xijiu Lake, where the industrial and urban activities were of the main human activities. This factor might be a reasonable interpretation of the clear differences in heavy metal enrichment in the four lakes.

3.3 Anthropogenic contribution to the heavy metals in the sediment

The heavy metal enrichment in the sediment was strongly related to human activities in the catchment. The mass accumulation flux could reflect the anthropogenic contribution to heavy metals in the sediment more exactly than their concentrations (Yohn et al., 2002; Liu et al., 2007a; Wu et al., 2008). The modern industrialization and urbanization started in the 1930s in the mid-low reaches of Yangtze River (Yang et al., 2002a, 2002b; Liu et al., 2007b). Therefore, the mean concentrations of heavy metals prior to the 1930s were used as the relative reference concentrations in order to discuss the modern anthropogenic contribution to the metal enrichment in the sediment of the four lakes. The mass accumulation flux and anthropogenic accumulation flux \( F_A \) of heavy metals were calculated by Eq. (2) (Klump et al., 1997):

\[
F_z = \omega \times S_z
\]

where, \( \omega \) is the MARs and \( S_z \) represented the metal concentrations in the \( z \)th sediment depth. The results are shown in Table 2 and Fig. 5.

The mass accumulation fluxes of heavy metals were highest in Xijiu Lake, followed by Taibai Lake and Longgan Lake and then Chaohu Lake. This differentiation was mainly attributed to the different MARs in the sediment (Fig. 2), which affected the mass of dry materials entering the lakes. Negative values of the anthropogenic accumulation flux represented lower anthropogenic contribution to the metal accumulation in the sediment. The anthropogenic accumulation fluxes of all heavy metals in Taibai Lake, Longgan Lake and Chaohu Lake as well as the values for Co, Cr and Ni in Xijiu Lake were lower, while higher values occurred for Cu, Pb and Zn in Xijiu Lake, which indicated the anthropogenic input of these metals. Meanwhile, Pearson correlation analysis (data not shown) also indicated that there was no significantly negative correlation of Cu, Pb and Zn with the grain size (expressed as the size of median particles, \( p < 0.01 \)) in the sediment of Chaohu Lake and Xijiu Lake, which further confirmed the anthropogenic contribution to these lakes.

The ratio of anthropogenic accumulation flux to mass accumulation flux \( (F_{A}/F_M) \) was first applied to indicate the anthropogenic contribution to heavy metals. The highest \( F_{A}/F_M \) ratios of heavy metals in both Taibai Lake and Longgan Lake were lower than 30\%, and the highest values were also lower than 30\% for Co, Cr and Ni in Chaohu Lake and Xijiu Lake. However, there were different patterns of \( F_{A}/F_M \) ratios for Cu, Pb and Zn in Chaohu Lake and Xijiu Lake. Since the 1950s, the \( F_{A}/F_M \) ratios were between 0.3\% and 55.8\% with mean value of 31.9\% for Cu, between 12.6\% and 53.7\% with mean value of 39.1\% for Pb and between 4.6\% and 70.5\% with mean value of 51.1\% for Zn in the Chaohu Lake. In Xijiu Lake, higher Cu enrichment occurred between 1985 AD and 2000 AD (Fig. 4), when the \( F_{A}/F_M \) ratios varied between 4.7\% and 43.3\% with mean value of 24.5\%. In the past 100 years, the \( F_{A}/F_M \) ratios of Pb varied between 0.3\% and 55.4\% with mean value of 35.4\%, and the ratios of Zn varied between 32.2\% and 81.8\% with mean value of 64.2\%. The \( F_{A}/F_M \) ratios of Cu, Pb and Zn in Chaohu Lake and Xijiu Lake clearly showed that modern human activities resulted in large accumulation of these metals in the sediment. Since the mean concentrations of heavy metals before modern industrialization and urbanization (prior to the 1930s) was used as the background to cal-

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Mass accumulation fluxes ( F_M ) and anthropogenic accumulation fluxes ( F_A ) in the four lake sediment (unit: ( 10^{-3} ) mg/(cm²·yr))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taibai Lake</td>
<td>Longgan Lake</td>
</tr>
<tr>
<td>( F_M )</td>
<td>( F_A )</td>
</tr>
<tr>
<td>Co</td>
<td>6.1</td>
</tr>
<tr>
<td>Cr</td>
<td>29.2</td>
</tr>
<tr>
<td>Cu</td>
<td>8.9</td>
</tr>
<tr>
<td>Ni</td>
<td>12.3</td>
</tr>
<tr>
<td>Pb</td>
<td>13.5</td>
</tr>
<tr>
<td>Zn</td>
<td>24.0</td>
</tr>
</tbody>
</table>

Data were expressed as mean values.
calculate the anthropogenic accumulation fluxes rather than the pristine background or the concentrations before human settlements, the anthropogenic contribution to heavy metals might be underestimated in the four lakes.

Although the anthropogenic accumulation fluxes of heavy metals in Taibai Lake and Longgan Lake were low, the evidence of anthropogenic impact could also be found by their mass accumulation fluxes (Fig. 5). The low fluxes between 1967 AD and 1988 AD in Taibai Lake and the decreasing fluxes since the 1950s in Longgan Lake were attributed to the construction of dams and reservoirs around the lakes, which caused a reduction of
material inputs (Liu et al., 2007b; Wu et al., 2010a). The increasing fluxes since 1988 AD in Taibai Lake were related to the transition to modern agricultural production patterns (Liu et al., 2007b). In Chaohu Lake and Xijiu Lake, the vertical variation of both mass accumulation fluxes and anthropogenic accumulation fluxes was similar to that of enrichment factors, indicating that the modern industrialization and urbanization indeed induced some heavy metal enrichment or contamination in the lakes.

4 Conclusions

The enrichment state of heavy metals was low in the sediment of Taibai Lake and Longgan Lake. The state of Co, Cr and Ni enrichment was also at a low level in the sediment of Chaohu Lake and Xijiu Lake, while Cu, Pb and Zn enrichment was at a higher level. Heavy metal accumulation varied little in the sediment of Taibai Lake and Longgan Lake, while that in Chaohu Lake and Xijiu Lake increased since the 1950s and substantially increased since the 1980s, although a decrease took place since 2000 AD in the Xijiu Lake. The differences in heavy metal enrichment were strongly related to the type and intensity of human activities in the catchments. In the catchments of Chaohu Lake and Xijiu Lake, the development of urbanization and industrialization was rapid, which accelerated the heavy metal accumulation in the sediment. Agricultural production was the main human activity in the catchments of Taibai Lake and Longgan Lake, which contributed a relatively small portion of heavy metals into the lakes. The quantitative results from the mass accumulation fluxes showed that the anthropogenic contribution to heavy metals was small in Taibai Lake and Longgan Lake, while heavy metals entering Chaohu Lake and Xijiu Lake, especially Cu, Pb and Zn, were mainly from anthropogenic contributions.

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References


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