Phosphorus release characteristics of different trophic lake sediments under simulative disturbing conditions

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Abstract

The effect of simulative disturbing on phosphorus (P) release characteristics and the differences of the P buffering capacity of different trophic lake sediments were investigated. The magnitudes of the dissolved total phosphorus (DTP), soluble reactive phosphorus (SRP) and dissolved organic phosphorus (DOP) released from the studied sediments increased with the increasing of disturbing intensity. The equilibrium time of the DTP release from the heavily polluted sediments was approximately 16 h, and that from the slightly polluted sediments was 8 h. This may be related to the difference of P forms in the different trophic sediments. About 30% of the DTP released from Wuli Lake and Yue Lake was from DOP, about 60% and 50%, respectively, was from Gonghu Lake and East Taihu Lake. DOP was the important fraction of DTP released. The effect of disturbing on P release was related to both disturbing intensity and sediment pollution level. After the disturbing stop, the DTP, SRP and DOP concentrations in the overlying water of the different sediments decreased rapidly within 3, 10 and 3 h, respectively, then gradually reached equilibrium at different time for the sediments with different pollution level. The different trophic lake sediments had different P buffering capacity, P buffering capacity of the slightly polluted sediments was lower at the initial lower SRP concentrations and was higher at the initial higher than that of the heavily polluted sediments.

Keywords:
Phosphorus release
Kinetics
Different trophic sediment
Disturbing intensity
Phosphorus buffering capacity

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1. Introduction

Sediments play an important role in overall phosphorus (P) cycling in shallow lake ecosystem, acting both as a sink and a source of P due to continuous transport of chemical species across the sediment–water interface [1], so the P concentration of the water column in shallow lakes can be buffered by sediments [2,3]. In many shallow lakes the resuspended material disturbed by wind, internal seiche activities and so on was the majority of the flux of P from sediments to the overlying water, and resulted in the redistribution of P at sediment–water interface [4–6]. Therefore, the sediment–water interface of shallow lakes is an important environment where P can be recycled for many times [7]. So the studies about P release characteristics under disturbed condition can reveal the real going of P in sediments [8], and this may help to understand the contribution of the P in sediments to the lake eutrophication [9,10].

However, so far little has been done regarding P release under disturbed condition [11,12]. Moreover, most of previous studies about P release mainly focused on the soluble reactive phosphorus (SRP) [13–15], and the release of dissolved organic phosphorus (DOP) was often ignored. In fact, DOP in lake ecosystems was an important P source for aquatic organisms [16–18]. In order to understand the P biogeochemical cycling, more attention should be paid to the DTP release from lake sediments [19,20]. At the same time the previous studies have shown that the magnitude of the P released (MPR) was different among the different trophic sediments [21,22], it is also important to understand the differences of the P buffering capacity of the different trophic sediments [23,24]. Therefore, the objective of this study was to understand the SRP and DOP release characteristics of different trophic lake sediments under simulative disturbing condition, and to determine their differences.
2. Materials and methods

2.1. Study areas

Sediments used in this study were collected from four lakes (Yue Lake, Wuli Lake, East Taihu Lake and Gonghu Lake) in the middle and lower reaches of Yangtze River (Fig. 1), the highest lake density area in China [25]. Yue Lake (29°58′N, 113°41′E) is located in Wuhan City, Hubei Province and is an urban lake with a surface area of 0.7 km². It is in hypereutrophication [21]. Wuli Lake (31°31′–23′N, 120°16′–35′E) is located in Jiangsu Province and is at the Taihu Lake’s northwestern tip with a population of 1 million in its watershed approximately 2 km to the northeast. It receives millions of tons of industrial wastewater and domestic sewage each day from Wuxi City, and is also in hypereutrophication [26]. East Taihu Lake (31°10′–206′N, 120°19′–477′E) is located in the southeastern corner of Taihu Lake near the town of Xishan in Jiangsu Province. It is a large and shallow bay, in which there are abundant aquatic plants. Its water quality remains good and is in mesotrophication [27]. Gonghu Lake (31°24′–843′N, 120°15′–242′E) is located at northeast portion of Taihu Lake, and it has a vast water surface, good fluidity and a high capacity of oxygen restoration. Large submerged plants were found in this part of Taihu Lake, and lake water had fairly good quality and was also in mesotrophication [28].

2.2. Sediment sampling and pollution level

The lake sediments were collected in September 2003, and were taken to the laboratory in sealed plastic bags in iceboxes, were then freeze-dried, and sieved with a standard 100 mesh sieve for further experiments. All physical–chemical properties of the sediments had been reported in a previous report [29]. According to the Chinese environmental dredging common standard, when the total phosphorus concentration in sediment was over 500 mg kg⁻¹, the lake sediment was considered as heavily polluted, and should be dredged [30]. So the studied sediments represented different trophic status, namely the sediments from Wuli Lake and Yue Lake were heavily polluted, and those from East Taihu Lake and Gonghu Lake were slightly polluted.

2.3. P release kinetic experiments

It is well known that there are many ions in the overlying water of shallow lakes, such as K⁺, Ca²⁺, Mg²⁺, Cl⁻, SO₄²⁻. Therefore, according to the previous studies [31–33], 0.02 M KCl solution was used as the simulative lake water with some ionic strength. Release kinetic experiments were performed in centrifuge tubes, and the detailed processes are shown as follows: 0.5 g dried sediment samples were added in a series of 100 ml acid washed centrifuge tubes with 50 ml of 0.02 M KCl solution. The centrifuge tubes were capped and placed at 25 °C, in an orbital shaker for various time intervals between 0 and 60 h (0, 0.25, 0.5, 1, 3, 5, 8, 16, 24, 40 and 60 h) at 60, 150 and 200 rpm, respectively. The sampled solution was immediately centrifuged at 5000 g for 10 min, and was then filtered through 0.45 μm GF/C filter membranes. The filtrate was taken for SRP and DTP analyses. SRP was analyzed using the molybdenum blue method [34]. DTP was measured as SRP after acid hydrolysis under UV irradiation, and was then determined using molybdenum blue method [35]. DOP was defined as the difference between DTP and SRP, and was only the approximate estimate of DOP and possibly contained colloidal P [36]. The quantity of released SRP, DTP and DOP can be calculated according to the increase of SRP, DTP and DOP concentrations in the solutions. For all samples, triplicate experiments were carried out and the data were expressed as their average. The results showed that standard error deviation was within 5% in the experiments.

2.4. P decrease kinetic measurements after simulative disturbing

Decrease kinetic experiments were also performed in centrifuge tubes. Like release kinetic experiments, 0.5 g dried sediment samples were added in a series of 100 ml acid washed centrifuge tubes with 50 ml of 0.02 M KCl solution. The centrifuge tubes were capped and placed at 25 °C, in an orbital shaker at 60, 150 and 200 rpm, respectively, for 24 h. After that the centrifuge tubes were kept resting for various time intervals between 0 and 60 h (0.25, 0.5, 1, 3, 5, 8, 16, 24, 40 and 60 h). The concentrations of SRP, DTP and DOP of the sampled solutions were determined as in the Section 2.3. For all samples, triplicate experiments were carried out and the data
were expressed as their average. The results showed that standard error deviation was within 6% in the experiments.

2.5. P buffering capacity experiments

Five initial P concentrations were chosen to conduct the P buffering capacity experiments (0.02, 0.1, 0.5, 1 and 2 mg l\(^{-1}\)). 0.5 g dried sediment samples were added in a series of 100 ml acid washed centrifuge tubes with 50 ml of 0.02 M KCl solution. The centrifuge tubes were capped and placed at 25 °C, in an orbital shaker at 250 rpm for 24 h. After that the SRP concentrations of the sampled solutions were determined as in the Section 2.3. The P buffering capacity of sediments can be calculated by the difference in SRP concentration before and after the P buffering capacity experiments [4]. SRP concentrations of the overlying water would increase due to the P release from sediments when the value of the P buffering capacity was positive, and that was the positive P buffering capacity. The negative P buffering capacity was that the SRP concentration of the overlying water would decrease by the P sorption on sediments. The stronger the P buffering capacity was, and the higher the
Fig. 4. The released DOP with different time during the phosphorus release experiments for the studied sediments.

absolute value of the P buffering capacity was. For all samples, triplicate experiments were carried out and the data were expressed as their average. The results showed that standard error deviation was within 6% in the experiments.

3. Results and discussion

3.1. P release characteristics of sediments under simulative disturbing condition

In natural condition, P sorption and release at sediment–water interface occurred at the same time [37]. The comparison of P release and sorption can determine if sediments acted as a source (MPR > the magnitude of P sorption (MPS)), sink (the MPR < the MPS) or in equilibrium (the MPR = the MPS) of P [12]. Under the disturbing of wind or biology, the magnitude of P release may exceed that of P sorption, at this condition sediments acted as a source of P [4]. Figs. 2–4 show that the processes of SRP, DOP and DTP releases in all the studied sediments were similar, generally containing a quick and slow reaction. The magnitudes of DTP, SRP and DOP release from the studied sediments increased with the increasing of the disturbing intensity. The equilibrium time of the DTP release from the heavily polluted sediments was about 16 h, and that of the slightly polluted sediment was about 8 h. This may be related to the difference of P forms in the different trophic sediments and the combined ways between the different P forms and the sediments. The concentrations of OP and Fe/Al–P in the heavily polluted sediments from Yue Lake and Wuli Lake were higher than those of the slightly polluted sediments from East Taihu Lake and Gonghu Lake (Fig. 5), and OP can be transferred into dissolved P under the process of phosphatase catalysis, and Fe/Al–P, an inorganic P, was easy to be released into the overlying water [29]. Ligand exchange has been proposed and investigated for the adsorption of phosphate on Fe and Al oxyhydroxides. In this reaction, the hydroxyl group of phosphate substitutes for the coordinated hydroxyl on Fe or Al oxyhydroxide surface [38]. Qualls also indicated that ligand exchange was the major adsorption mechanism of inorganic–organic interactions, hydrogen bonding and Van der Waals forces were important in controlling sorption behavior of soluble organic–solid organic interactions [39]. The surface of colloid organic matter (OM) contains a large content of oxygen-function groups, which compose the main part of the functional groups. The negative charges of the organic colloid in sediments mainly come from the H⁺ dissociation of the oxygen-function groups, e.g., carboxyl and phenolic hydroxyl. Those groups are the key factor controlling the cationic adsorption behavior on the organic colloid. In the heavily polluted sediments from Yue Lake and Wuli Lake, OM content was higher that in the slightly polluted sediments from East Taihu Lake and Gonghu Lake, and OM adsorbed onto the clay surfaces blocked the P exchange sites [40]. At the same time, in natural conditions, OM is the nutritional basis of bacteria playing an important role in the formation of P concentration in interstitial waters, so the sediment with the highest OM content has the maximum number of bacteria, the highest rate of OM mineralization, and the maximal P release capacity [41,42]. Therefore, the equilibrium time of the DTP release in Yue

Fig. 5. Concentrations of the different phosphorus forms in the studied sediments.
Lake and Wuli Lake sediments was longer than that from East Taihu Lake and Gonghu Lake sediments.

Some algae were capable of obtaining P directly from DOP in the absence of dissolved inorganic phosphorus (DIP) to sustain their growth [18]. Therefore, DOP in lake ecosystems was also an important P source for aquatic organisms. In this study, for most of the experimental time, approximately 30% of the DTP released from Wuli Lake and Yue Lake was from DOP, and 60% and 50%, respectively, for Gonghu Lake and East Taihu Lake. This indicates that DOP was the important fraction of DTP released from sediments, especially for the slightly polluted sediments, and it cannot be neglected. This is similar to some previous studies [16,43]. Approximately one-third of the DTP of the overlying water in Hiroshima Bay was DOP [44]. The rapid recycling of some DOP indicates biological availability [45]. All those clearly show that DOP was an important P source [46], and the magnitude of DOP released from sediments should not be neglected. Furthermore, in some condition, DOP may become the main fraction of DTP released from sediments.

Disturbing intensity was one of the important factors that affected the P release from sediments (Figs. 2–4). Power function model is one of the important kinetic models that are usually used to analyze the process of P release from sediments. In this investigation, this model was used to fit the process of SRP, DOP and DTP release from the studied sediments, and the calculated parameters of the kinetics model are shown in Table 1. Based on $R^2$ and S.E., power function model can satisfactorily describe the SRP, DOP and DTP release kinetics.

$k$ is the release rate constant, and was once used to indicate the relative extent of SRP release from soils in a previous study [47]. In this study, $k$ was used to reflect the relative extent of SRP, DOP and DTP release from sediments. The rank order of the SRP, DOP and DTP release was the heavily polluted sediments from Yue Lake and Wuli Lake > the slightly polluted sediments from East Taihu Lake and Gonghu Lake, which related to that the content of organic P in the heavily polluted sediments is higher than that in the slightly polluted sediments. The magnitude of the SRP, DOP and DTP released increased with the increasing of the disturbing intensity. For different treatments, the rank order of the heavily polluted sediments from Yue Lake and Wuli Lake was: DTP > DOP > SRP, and for the slightly polluted sediments from East Taihu Lake and Gonghu Lake the rank order was: DTP > DOP > SRP (Figs. 2–4). This result provides further support that DOP was also an important fraction of DTP released, and cannot be neglected, especially for the slightly polluted sediments (Fig. 5).

3.2. Decrease of P concentration in the overlying water after simulated disturbing

At the beginning of the disturbing stop, the stronger the disturbing intensities were, the higher initial P concentrations in the overlying water (Figs. 6–8). This is because the amount of P released from sediment increased with the increasing of disturbing intensities, the action of P release gradually replaced the action of P diffuse from sediments into overlying water with the increasing of disturbing intensities [48,49]. After the disturbing stop, the change trend of

### Table 1

Estimated kinetic parameters for DTP, SRP and DOP release from the studied sediments

<table>
<thead>
<tr>
<th>Phosphorus type</th>
<th>Sediments</th>
<th>rpm</th>
<th>$q = a + k \cdot n \cdot t$</th>
<th>$a$</th>
<th>$k$</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTP</td>
<td>Yue Lake</td>
<td>200</td>
<td>13.53 ± 0.61</td>
<td>2.68 ± 0.32</td>
<td>0.92</td>
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<tr>
<td></td>
<td></td>
<td>150</td>
<td>11.92 ± 0.24</td>
<td>1.35 ± 0.13</td>
<td>0.95</td>
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<tr>
<td></td>
<td></td>
<td>60</td>
<td>10.44 ± 0.31</td>
<td>0.83 ± 0.16</td>
<td>0.81</td>
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</tr>
<tr>
<td></td>
<td>Wuli Lake</td>
<td>200</td>
<td>8.26 ± 0.20</td>
<td>0.87 ± 0.11</td>
<td>0.92</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>150</td>
<td>6.44 ± 0.15</td>
<td>0.41 ± 0.08</td>
<td>0.81</td>
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<td></td>
<td></td>
<td>60</td>
<td>5.96 ± 0.16</td>
<td>0.28 ± 0.05</td>
<td>0.83</td>
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</tr>
<tr>
<td></td>
<td>Gong Lake</td>
<td>200</td>
<td>1.91 ± 0.10</td>
<td>0.23 ± 0.05</td>
<td>0.75</td>
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<tr>
<td></td>
<td></td>
<td>150</td>
<td>1.36 ± 0.05</td>
<td>0.20 ± 0.03</td>
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<td></td>
<td></td>
<td>60</td>
<td>0.96 ± 0.06</td>
<td>0.18 ± 0.03</td>
<td>0.89</td>
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<tr>
<td></td>
<td>East Taihu Lake</td>
<td>200</td>
<td>1.68 ± 0.08</td>
<td>0.19 ± 0.04</td>
<td>0.74</td>
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<tr>
<td></td>
<td></td>
<td>150</td>
<td>0.87 ± 0.05</td>
<td>0.14 ± 0.03</td>
<td>0.75</td>
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<td></td>
<td></td>
<td>60</td>
<td>0.62 ± 0.03</td>
<td>0.11 ± 0.02</td>
<td>0.93</td>
<td></td>
</tr>
<tr>
<td>SRP</td>
<td>Yue Lake</td>
<td>200</td>
<td>9.26 ± 0.59</td>
<td>1.91 ± 0.32</td>
<td>0.86</td>
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<td></td>
<td></td>
<td>150</td>
<td>8.19 ± 0.16</td>
<td>0.78 ± 0.08</td>
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<td></td>
<td></td>
<td>60</td>
<td>7.21 ± 0.22</td>
<td>0.53 ± 0.12</td>
<td>0.77</td>
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<tr>
<td></td>
<td>Wuli Lake</td>
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<td>5.41 ± 0.10</td>
<td>0.53 ± 0.05</td>
<td>0.95</td>
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<td></td>
<td></td>
<td>150</td>
<td>4.23 ± 0.10</td>
<td>0.32 ± 0.05</td>
<td>0.86</td>
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<td></td>
<td></td>
<td>60</td>
<td>3.99 ± 0.04</td>
<td>0.33 ± 0.02</td>
<td>0.97</td>
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<td></td>
<td>Gong Lake</td>
<td>200</td>
<td>0.42 ± 0.01</td>
<td>0.08 ± 0.01</td>
<td>0.97</td>
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<tr>
<td></td>
<td></td>
<td>150</td>
<td>0.37 ± 0.02</td>
<td>0.05 ± 0.01</td>
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<td></td>
<td></td>
<td>60</td>
<td>0.26 ± 0.02</td>
<td>0.03 ± 0.01</td>
<td>0.81</td>
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<tr>
<td></td>
<td>East Taihu Lake</td>
<td>200</td>
<td>0.73 ± 0.04</td>
<td>0.17 ± 0.02</td>
<td>0.93</td>
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<td></td>
<td></td>
<td>150</td>
<td>0.47 ± 0.03</td>
<td>0.09 ± 0.02</td>
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<td></td>
<td></td>
<td>60</td>
<td>0.32 ± 0.01</td>
<td>0.07 ± 0.00</td>
<td>0.99</td>
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<tr>
<td>DOP</td>
<td>Yue Lake</td>
<td>200</td>
<td>4.32 ± 0.37</td>
<td>1.09 ± 0.28</td>
<td>0.79</td>
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<td></td>
<td></td>
<td>150</td>
<td>3.73 ± 0.11</td>
<td>0.57 ± 0.06</td>
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<td></td>
<td></td>
<td>60</td>
<td>3.23 ± 0.11</td>
<td>0.30 ± 0.06</td>
<td>0.80</td>
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</tr>
<tr>
<td></td>
<td>Wuli Lake</td>
<td>200</td>
<td>2.15 ± 0.23</td>
<td>0.94 ± 0.18</td>
<td>0.88</td>
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<tr>
<td></td>
<td></td>
<td>150</td>
<td>2.17 ± 0.06</td>
<td>0.18 ± 0.05</td>
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<td></td>
<td></td>
<td>60</td>
<td>1.91 ± 0.03</td>
<td>0.15 ± 0.02</td>
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<tr>
<td></td>
<td>Gong Lake</td>
<td>200</td>
<td>1.50 ± 0.07</td>
<td>0.26 ± 0.05</td>
<td>0.87</td>
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<td>1.00 ± 0.05</td>
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<td></td>
<td></td>
<td>60</td>
<td>0.70 ± 0.04</td>
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<tr>
<td></td>
<td>East Taihu Lake</td>
<td>200</td>
<td>0.98 ± 0.02</td>
<td>0.10 ± 0.01</td>
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<td></td>
<td></td>
<td>150</td>
<td>0.41 ± 0.03</td>
<td>0.07 ± 0.03</td>
<td>0.82</td>
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<td></td>
<td></td>
<td>60</td>
<td>0.31 ± 0.02</td>
<td>0.04 ± 0.02</td>
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</table>
DTP, SRP and DOP concentrations of the overlying water in different sediment was similar, but the persisting time was different. The DTP concentrations in the overlying water of the heavily polluted sediments decreased rapidly with the resting time increasing within the first 3 h, and then gradually reached equilibrium after 10 h. For the slightly polluted sediments they also decreased rapidly within the first 3 h, but equilibrium time was about 20 h. That of SRP in the heavily polluted sediments also decreased rapidly within the first 10 h, and finally their concentrations were similar to those at the beginning. For the slightly polluted sediments that of SRP decreased rapidly within the first 10 h, and then reached equilibrium gradually except for sediments from Gonghu Lake. The DOP concentrations in the overlying water of the heavily polluted sediments decreased rapidly within the first 3 h after simulating disturbing stop, and then reached equilibrium, and for the lightly polluted sediments the trend is similar. The suspended sediments, especially the larger sediment grain dropped rapidly at the first time and sorbed the SRP and DOP in the water column after the disturbing stop [50].
The larger sediment grain was, the larger sorbed areas was, and the higher amount of SRP and DOP can be sorbed [51], so the DTP, DOP and SRP concentrations of the overlying water decreased rapidly. With the time of after disturbing stop increasing, the SRP and DOP release and sorption gradually attained equilibrium [50], so the DTP, DOP and SRP concentrations in different sediments also gradually reached equilibrium. However, the reasons of difference of persisting time of DTP, SRP and DOP among different sediments need to be further studied.

In this study, the final SRP concentrations in the overlying water of the heavily polluted sediments after disturbing stopped were similar to those at the beginning. This indicates that for the heavily polluted sediments there was no significant effect on the SRP concentrations by disturbing due to the higher initial SRP concentrations in the overlying water [43]. With the resting time increasing DOP concentrations decreased, there was significant effect on DOP concentrations by disturbing. In natural field, after the stronger wind disturbing, DTP concentrations in the overlying water of shallow lake decreased as often observed [4], this may relate to the decrease in DOP concentrations.

In this study, after the stronger disturbing (200 and 150 rpm) and a period of resting time, DTP concentrations in the overlying water of the studied sediments decreased, showing that after the stronger disturbing the sediments can act as a sink for P. But the fact is that the water is always in dynamic condition, especially for the shallow lakes in China. After the disturbing the DTP concentration in the overlying water of shallow lakes in China can maintain relatively high level, and this provides necessary nutrition for eutrophication [43]. This is one of the reasons that it is difficult to control the shallow lake eutrophication in China and water blooms often occur after the stronger wind in Taihu Lake [52]. In addition, under the simulative disturbing condition the P release from sediments was affected intensively by the disturbing intensity, and the MPR increased with the increasing of disturbing intensity. This indicates that the effect of disturbing on the P concentration of overlying water was strong. Previous studies have shown that the relatively short-lived duration of dredging would prevent any significant effects on the dumpsite surroundings [53,54]. Therefore, more attention should be paid to the probable P release that was the negative environmental effect caused by dredging disturbing during the lake sediment dredged.

### 3.3. P buffering capacity of different trophic sediments

P release and adsorption are controlled by the buffering mechanism involving iron oxides at sediment surface [42]. When the P concentration of overlying water increased rapidly, the P pollution can be rapidly lighten by the P buffering capacity of sediments through sorption [55], and after the P concentration decreased, which can be maintained high through P release [3]. In natural field this action had more obvious effect on water quality in a short time than the natural dilution and bio-accumulation [56]. This was the reason that the P concentration of the overlying water increased in a short time after the polluted water was replaced with the non-polluted [30].

At the same initial SRP concentration condition, SRP concentrations in the overlying water of the different studied sediments were different after the P buffering capacity experiments (Fig. 9), which showed that the P buffering capacity of the sediments may relate to their pollution level [12]. The overlying water SRP concentrations of the heavily polluted sediments from the Yue Lake and Wuli Lake were higher than those of the slightly polluted sediments from East Taihu Lake and Gonghu Lake. Therefore, the different trophic lake sediments had different P buffering capacity, namely for the heavily polluted sediments its P buffering capacity can maintain a higher overlying water SRP concentration, and for the slightly polluted sediments it can maintain a lower [12].

The changes in SRP concentrations before and after the buffering capacity experiments were used to compare the P buffering capacity [55]. The estimated results of P buffering capacity of the studied sediments are shown in Fig. 10, and that of the slightly polluted sediments was lower at the initial lower SRP concentrations (0.02 and 0.1 mg/l) and was higher at the initial higher (0.5, 1 and 2 mg/l)
than that of the heavily polluted sediments, and this is different for the heavily polluted sediments (Fig. 10). SRP concentrations in the overlying water in most of shallow lakes in China were lower than 0.1 mg/l [57,58]. This indicates that the slightly polluted sediments had a lower P buffering capacity than the heavily polluted sediments.

The P release and adsorption processes occurred at the same time, and were the main actions in the compositive factors such as the overlying water SRP concentration and the disturbing intensity [59]. The process of P sorption was the main process in the higher overlying water SRP concentration and the weaker disturbing intensity [4]. So the sediments and overlying water were the natural P buffering system in lakes, and this can also be seen from Fig. 10, that lake sediments had the higher P buffering capacity, especially at higher initial SRP concentration.

4. Conclusions

In this study, P release kinetic experiments. P decrease kinetic measurements after simulative disturbing and P buffering capacity experiments were investigated in the sediments of four shallow lakes from the middle and lower reaches of Yangtze River region, China, and conclusions can be drawn as follows:

(1) The magnitudes of the DTP, SRP and DOP released from the studied sediments increased with the increase in the disturbing intensity. The equilibrium time of the DTP release from the heavily polluted sediments was approximately 16 h, and that from the slightly polluted sediments was 8 h.

(2) For most of the experimental time, about 30% of the DTP released from Wuli Lake and Yue Lake were from DOP, and for Gonghu Lake and East Taihu Lake that were about 60% and 50%, respectively. DOP was the important fraction of DTP released from the sediments, especially in the slightly polluted sediments.

(3) DTP, SRP and DOP release kinetic processes were initially rapid and were followed by a slower reaction. Power function model can be used to satisfactorily describe the DTP, SRP and DOP release kinetics.

(4) After the disturbing stop, the DTP, SRP and DOP concentrations in the overlying water of the different sediments decreased rapidly within 3, 10 and 3 h, respectively, then gradually reached equilibrium at different time for the sediments with different pollution level.

(5) P buffering capacity of the slightly polluted sediments was lower at the initial lower SRP concentrations and was higher at the initial higher than that of the heavily polluted sediments.

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References


