Approaches of Reutilizing Dredged Sediments from Beijing-Hangzhou Grand Canal

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Abstract. With the implementation of the dredging project in Beijing-Hangzhou Grand Canal, proper treatment of sediment is urgent. Analysis of samples revealed a spatial difference among sampling sites, varied degree of pollutions and a strong correlation among the pollutants implying a common source of origin. Based on the sediment quantity, the contamination status quo and relevant requirements in the standards, the sediments were categorized into three types with different disposal strategy. The majority of the sediment that is not polluted or mildly contaminated were to be relocated or used as planting soil and engineering backfill geomaterial. The heavily polluted sediments were to be transported and used in a local brick manufacturing plant render it harmless.

1. Introduction
There have been a substantial dredging and desilting projects of rivers, lakes and coastal water bodies in recent years to improve the water quality as well as to ensure the anti-flooding and navigational capacity of water bodies. Hangzhou City of Zhejiang in China had recently initiated the dredging project of the second channel of the Beijing-Hangzhou Grand Canal. Preliminary studies had indicated that the Hangzhou Section of Beijing-Hangzhou Grand Canal (HSBGC) dredging project would generate a total amount of 69,500 m³, covering a total of 4 river channels including Wo Fung Harbour, Shang Tang River, Ting Toe Harbour and Ochre Hill Harbour, with a total dredging length of 42.3km. Based on the previous researches, the dredged sediment is often characterized with high water content, low strength and sometimes polluted with heavy metals, organic matter, N, P and other pollutants. [1] Proper handling of sediment in respect to the pollutants is important and its management is becoming an issue of concern.

In this study, we have performed an integrated investigation of pollutants and exams their correlations using Pearson’s methods. A strategy for promoting sustainable management of sediment was then proposed with the aim of mitigating adverse impacts and assisting the development of overall plan for the dredging project to come.

2. Materials and Methods
The sampling locations of the tested sediment is distributed evenly within 4 river channels aforementioned. Eleven sampling sections were selected to ensure the representativeness with 3 samples at each site to form a mixed sample. The sampling sections are marked as T1~T11 in the figure 1.
The samples were air dried, milled and sieved before acid digestion. Place 0.25g of each sample in Teflon vessel, with 5mL of HNO₃ and 5mL of HF added. The samples were then heated at 118°C for 2 min before 5~10ml of 30% H₂O₂ was added droplet. Afterwards, heating the solutions to evaporate till 5 ml and cooling to room temperature, then add 2~5 mL of saturated boric acid before diluted to 25 ml. The resulting digest was filtered and sealed. Samples were analysed using an air-acetylene flame atomic absorption spectrophotometer. Protocols were followed as described in “Emission Standards for Pollutants from Urban Sewage Treatment Plants” (GB18918-2002).

3. Results and Discussions

3.1. Enrichment Factor

According to the analysis data, the sediment is neutral and weakly alkaline (pH 7.0 ~8.7). The texture is sticky most of which belongs to the medium loam to light clay. The content of heavy metals and total petroleum hydrocarbon (TPH) in the sediment at 11 sampling site are shown in figure 2 and 3. The concentrations of heavy metals in the varied sites showed a wide variation. Since no criteria in river sediments exist nowadays, we compared the heavy metal concentrations with the average shale values from Zhejiang Geological Survey Institute[2] as background values (given as GV). Nearly 50% of sites showed heavy metals accumulation mainly at site T2, T3, T4, T7, T10 distributed in the Wo Fung Harbor, Shang Tang River and Ting Toe Harbor. In contrast, Ochre Hill Harbor showed no heavy metal pollutions. For each pollutant, the concentrations in each sampling site were quite different. For example, TPH concentration in T10 is low while other heavy metals exceed those of GV.
3.2. Correlation analysis of pollutants

In the correlation analysis for HSBGC sediments, Pearson’s correlation coefficients (r) were calculated from the mean concentrations of heavy metals. The Pearson’s correlation matrix as in Table 1 showed that all seven heavy metals are extremely strong positively correlated to one another indicating common pollutant sources [3, 4] or similarity in geochemical behaviour [5]. Meanwhile TPH also demonstrated strong positive correlations with heavy metals that suggest a common origin of petrol station or automobile repair shops.

Table 1. Pearson’s correlation coefficients between heavy metals of HSBGC sediments

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<thead>
<tr>
<th></th>
<th>Cd</th>
<th>As</th>
<th>Pb</th>
<th>Cu</th>
<th>Ni</th>
<th>Zn</th>
<th>Cr</th>
<th>TP</th>
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<tbody>
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<td>Cd</td>
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<td></td>
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<tr>
<td>As</td>
<td>0.743</td>
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<td>Pb</td>
<td>0.939</td>
<td>0.831</td>
<td>0.887</td>
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<tr>
<td>Cu</td>
<td>0.698</td>
<td>0.865</td>
<td>0.842</td>
<td>0.874</td>
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<tr>
<td>Ni</td>
<td>0.915</td>
<td>0.816</td>
<td>0.903</td>
<td>0.995</td>
<td>0.882</td>
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<tr>
<td>Zn</td>
<td>0.753</td>
<td>0.832</td>
<td>0.807</td>
<td>0.886</td>
<td>0.925</td>
<td>0.896</td>
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<tr>
<td>Cr</td>
<td>0.996</td>
<td>0.717</td>
<td>0.717</td>
<td>0.917</td>
<td>0.652</td>
<td>0.891</td>
<td>0.701</td>
<td></td>
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<tr>
<td>TP</td>
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*Significant correlation at the 0.05 level (one-tailed).
**Significant correlation at the 0.01 level (two-tailed).

3.3. Sediment Utilization Schemes

In most cases, sediment was either disposed or relocated. [6] Disposal is the transport and dump of sediment to a marine disposal area or landfill area designated by the authorities. Relocate is to transport and store river and lake sediment in low-lying areas (e.g. fish ponds, cultivated areas, etc.) for permanent or temporary stockpiling followed by replanting. With the emphasis on environmental protection, disposal and relocation are gradually being rigorously restrained by various authorities. Instead resource recovery methods were proposed such as land use [7], engineered backfilling [8] and building material use [9]. Based on the quantity, the contamination status quo and relevant requirements in the “Soil environmental quality Soil contamination risk management standards for construction sites” (GB36600-2018) and “Soil Environmental Quality Soil Contamination Risk Management Standards for Agricultural Land” (GB15618-2018), varied approaches of reutilizing HSBGC sediment is proposed categorizing sediments as type I, II and II. Type I sediment is estimated to be 488,000 m³ which meet the requirement of GB15618-2018, hence can be used for Agricultural Land. After preliminary communication, local authorities provided 4 lotus ponds or sablefish ponds in Xingwang Village, Bolu Village and Qi Jiaqiao Village to accommodate type I sediment with a capacity up to 539,000 m³. The land use of sediment realizes its resource recovery and brings the sediment back into the natural material and energy cycle. Type II sediment is estimated to be 177,000 m³ which meet the requirement of GB36600-2018 but not GB15618-2018, hence can be used both as planting soil for greening and engineering
backfill geomaterial considering that Linping New Town is undergoing an area-wide land remediation project, which requires a large amount of soil for planting and backfilling materials for engineering. It not only dissipates a large amount of sediment but also alleviates the shortage of soil and rock resources. Type III sediment is estimated to be 29,000 m³ which are characterized by heavy metals and organic pesticide pollutants. Failing to meet the requirement of national standards, it is proper to transfer type III sediments to a local brick plant which can provide up to 100,000 m³ capacity annually. It increases the source of raw materials for the building material industry by replacing nonrenewable clay with renewable sediment.[10]

4. Conclusions

With the implementation of the dredging project, a large amount of sediment were to be discharged in short term, and the proper disposal of sediment has become the bottleneck in the dredging project. The analysis of physicochemical characteristics of sediment was conducted to find the most economical and effective disposal method. It seems that relocation and land use may be a feasible way to solve a large sum of dredged sediment from current project under the effective management by categorizing sediment into three types. Type III sediment is mostly polluted and more appropriated to be used in a local brick plant render it harmless and resourceful. Type II sediment can be used as planting soil or engineering filling, yet on-site ecotoxicological studies are needed for further investigation to elucidate the linkage between sediments and surrounding ecological system.

References