Copper and Lead Concentrations in Water, Sediments, and Tissues of Asian Clams (*Corbicula* sp.) in Bung Boraphet Reservoir in Northern Thailand (2008)

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**Abstract**

Bung Boraphet is the largest freshwater reservoir in Thailand. This study examined the accumulation of copper (Cu) and lead (Pb) in water, sediment and tissues of Asian clams (*Corbicula* sp.) within Bung Boraphet to assess the possible polluting effect of soil erosion and the dissolution of water soluble salts from the Nan River. Samples were collected from 12 study sites within Bung Boraphet between February and December 2008. The physicochemical parameters of the water including temperature, pH, turbidity, ammonia nitrogen, nitrate nitrogen, orthophosphates, biochemical oxygen demand, dissolved oxygen, Cu, and Pb were measured. The water in Bung Boraphet was found to be medium clean according to the surface water quality standard of Thailand. The levels of Cu and Pb in the water were low but heavy metals were detected at higher levels in the sediment and tissues of *Corbicula* sp. In the near future, management practices and regulator approaches for Cu and Pb contamination will be needed to protect the water in Bung Boraphet.

**Keywords**: Bung Boraphet Reservoir, Bioaccumulation, Copper, *Corbicula* sp., Lead

**1. Introduction**

Bung Boraphet reservoir is a located in Nakhon Sawan Province, Northern Thailand. It was constructed in 1930 in an area of swamp at the confluence of the Nan River, which feeds into the Chao Phaya River. Bung Boraphet has high ecological and social economic value, particularly in its biodiversity according to the Office of Natural Resources and Environment Policy and Planning[1].

Bung Boraphet reservoir is a multiuse water body. It currently serves 30,000 people living around the reservoir, and has been used for water supply, flood control, waste disposal, fisheries, aquaculture, farming, etc. Heavy metals in Bung Boraphet originate from natural and artificial sources. Natural heavy metals introduced into the reservoir come primarily from such sources as soil erosion, and dissolution of water soluble salts from the Nan Rivers. The distribution of heavy metals in the sediment of Bung Boraphet between January and April 1993 was examined by Petpiroon et al.[2]. The zinc (Zn), lead (Pb), and cadmium (Cd) concentrations were at normal levels of 18.51, 12.99, and 0.12 Åg g⁻¹, respectively. However, Pb was the only metal that showed an increase in concentration. Cu at 23.50 Åg g⁻¹ was slightly higher than the normal level for earth sediment[2].

The benthos including aquatic snails, mussels, leeches, aquatic worms, and aquatic insects is an aggregation of organisms living on or at the bottom of a body of water. Mussels are filter feeders that live in the sea, lake or river bottom sediment for a few years. Therefore, mussels are commonly used as a monitoring organism. In general, the use of mussels as bioaccumulators of toxic metals has concentrated on analyses of their soft tissues. A previous study reported the presence of *Hyriopsis delaportae*, *Hyriopsis biaulatus Simson*, *Unio scobinata Lea*, *Unio thaiensis Habe*, *Ensidens ingallsianus*, *Pilobryoconcha exilis*, and *Corbicula* sp. in Bung Boraphet[3]. The *Corbicula* sp. is a widespread genus comprised of moderate sized clams, which are often tinged or colored violet on the interior. Duangsawadi [4] reported that *Corbicula* sp. is also present in Bung Boraphet at frequency of occurrence (%OC) of 7.24%.

The study examined the water quality including physical, chemical properties and to determine the concentration of heavy metals Cu and Pb in sediments, water, and tissues of *Corbicula* sp.

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2. Materials and Methods

2.1. Study Area

Bung Boraphet Reservoir is located between latitude 15°40′ - 15°45′ N and longitude 100°10′ -100°23′ E (approximately 20 m- meters above sea level) Nakhon Sawan Province, Thailand. The reservoir covers approximately 212.38 km². The average water depth is 1.6 meters (maximum of water depth is 5 meters). The reservoir turns into a grass-covered plain with scattered ponds and swampy depressions during the dry season. In this study, water, sediment and Corbicula sp. samples were collected every 2 months from 12 study sites around Bung Boraphet (Fig. 1) between February and December 2008.

2.2. Investigation of Water Quality in Bung Boraphet Reservoir

The water physicochemical parameters including temperature, pH, turbidity, ammonia nitrogen (NH₃-N), nitrate nitrogen (NO₃-N), orthophosphates (PO₄³⁻), biochemical oxygen demand (BOD), dissolved oxygen (DO), Cu, and Pb were examined according to the method reported by Eaton et al.[5].

2.3. Determination of Cu and Pb Concentrations in Water, Sediments, and Tissues of Corbicula sp. in Bung Boraphet Reservoir

Water samples were collected manually in polyethylene bottles. All bottles were cleaned with 10% HNO₃ and rinsed with distilled water prior to use. All water samples were collected at approximately 30 cm beneath the water surface prior to transfer directly to the bottles. In the preservation stage, after sedimentation, concentrated nitric acid was added to adjust the pH to < 2.

Sediment samples were collected using a specially modified Smith-McIntyre grab made from high grade stainless steel, while offshore samples were collected using a core sampler. The Corbicula sp. samples were collected from the field and taken to the laboratory. At least 10 clams (approximately 15-25 mm in length measured for the anterior-posterior shell length with Vernier calipers) were collected from a 500 m² area of each study site. The clam samples were kept in water until the digestion process on the next day.

The clam samples were washed gently with deionized water to remove any sediment particles retained in the gills and mantle cavity. The clams were dried at 40-50°C, according to the method reported by Barsyte Lovejoy[6]. Soft tissues of 5 to 10 individuals were removed from the shell prior to homogenization using a mortar according to the method reported by Jeffrey et al.[7]. Sediment samples were dried at 100°C in a hot air oven for 24 hours[8]. The dried sediment samples were crushed with an agate mortar. Depending on the availability of material, the homogenates were separated into two or three sub-samples for replicate analyses. The homogenized Corbicula sp. tissues were then transferred to acid-washed 250 mL conical flasks. Concentrated HNO₃ (5 mL) and concentrated H₂SO₄ (10 mL) and glass beads were added to the Corbicula sp. tissues. The mixtures were evaporated on a hot plate until dense white fumes of SO₃ began to appear[9]. For sediment digestion, 4 mL of concentrated HNO₃, 16 mL HCl and glass beads were added. The sediment mixtures were evaporated on a hot plate to a volume of approximately 5 mL. The digested samples were allowed to cool to approximately 55°C, followed by the further addition of concentrated HNO₃ 20% (25 mL). The flasks were returned to the...
Table 1. Physiochemical parameters measured in the sampling sites from Bung Boraphet in 2008

<table>
<thead>
<tr>
<th>Parameter</th>
<th>February</th>
<th>April</th>
<th>June</th>
<th>August</th>
<th>October</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>27.61±1.15</td>
<td>31.53±1.37</td>
<td>30.33±1.29</td>
<td>27.25±0.84</td>
<td>33.13±0.33</td>
<td>26.83±1.60</td>
</tr>
<tr>
<td>pH</td>
<td>7.70±0.48</td>
<td>8.43±1.01</td>
<td>8.47±1.08</td>
<td>7.67±0.48</td>
<td>7.25±0.73</td>
<td>7.14±0.84</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>6.70±8.60</td>
<td>7.01±9.94</td>
<td>6.66±9.81</td>
<td>7.06±8.85</td>
<td>6.69±9.01</td>
<td>5.86±8.73</td>
</tr>
<tr>
<td>DO (mg l⁻¹)</td>
<td>24.08±29.88</td>
<td>50±±53.66</td>
<td>71.58±91.60</td>
<td>60.33±48.09</td>
<td>19.42±4.12</td>
<td>21.08±5.45</td>
</tr>
<tr>
<td>BOD (mg l⁻¹)</td>
<td>4-95</td>
<td>5-195</td>
<td>7·276</td>
<td>16·184</td>
<td>12·26</td>
<td>13·29</td>
</tr>
<tr>
<td>NO₃ (µg l⁻¹)</td>
<td>232.48±40.48</td>
<td>658.08±466.51</td>
<td>108±115.63</td>
<td>773.38±653.70</td>
<td>703.33±744.30</td>
<td>26.08±5.25</td>
</tr>
<tr>
<td>NH₃ (µg l⁻¹)</td>
<td>157.69±311.54</td>
<td>38.50±1,577</td>
<td>0.295</td>
<td>0.1,577</td>
<td>0.710</td>
<td>22·40</td>
</tr>
<tr>
<td>PO₄ (µg l⁻¹)</td>
<td>65·416</td>
<td>64·428·88·14</td>
<td>58·918</td>
<td>65·955</td>
<td>240·950</td>
<td>177·646</td>
</tr>
</tbody>
</table>

For a given physiochemical parameters, mean concentrations followed by the same letter (a, b, c) are not significantly different (p<0.05). DO: dissolved oxygen, BOD: biochemical oxygen demand; NO₃: nitrate, NH₃: ammonia, PO₄: orthophosphates, ̅X: mean, SD: standard deviation, Min: minimum, Max: maximum.

3. Results and Discussion

3.1. Water Quality in Bung Boraphet Reservoir

Table 1 lists the physiochemical parameters of the water in Bung Boraphet between February and December 2008. The water temperature, pH, turbidity, DO, BOD, NH₃-N, NO₃-N, and PO₄-P were compared with the surface water quality standards of Thailand[11]. The assessment revealed the water quality of Bung Boraphet to be medium clean. It is suitable for human consumption and industrial purposes under sanitary controlled processes as well as agriculture. The water quality in this study was better than previous reported in 2006 by the Pollution Control Department[12]. The water quality was found to be poorer in the dry season than in the rainy season.

3.2. Distribution Study of Cu and Pb in Water Sediment and Tissues of Corbicula sp.

The concentration of heavy metals in water and sediments are presented in Tables 2 and 3 and Figs. 2 and 3. The levels of Cu and Pb were generally higher in the sediment than the clams and water, respectively. The highest concentration of Cu in the water of Bung Boraphet was observed in April (>2 µg l⁻¹). The concentrations of Cu were <2 µg l⁻¹ in February, June, August, and October, but <1 µg l⁻¹ in December. The highest Pb concentration (>5 µg l⁻¹) in water was detected in April while <5 µg l⁻¹ was detected in August. The same Pb concentrations of <4 µg l⁻¹ were observed in February, June, October, and December. The levels of Cu and Pb were satisfactory according to surface water quality standards of Thailand (≤0.1 and 0.05 mg l⁻¹ for Cu and Pb, respectively)[11].

The Cu and Pb concentrations in the sediments were between 28.73-41.15 mg kg⁻¹ and 16.44-26.89 mg kg⁻¹, respectively. There is no standard established for the bottom sediments in Thailand. Therefore, the concentrations of the metals in the Bung Boraphet sediments were compared with the recommended lowest levels for Canadian sediment quality guidelines for the protection of aquatic life (≤35.7 and 35 mg kg⁻¹ dry wt. for Cu and Pb, respectively)[13]. However, the concentrations of Cu in the sediments exceed the Canadian standard in June.

Higher concentrations of heavy metals in the sediment than in water were observed in this and other studies[6, 14-16]. Sediment is the major repository of metals, in some cases, holding more than 99 percent of the total amount of metal present in an aquatic
Table 2. Concentrations of Cu and Pb in the water from Bung Boraphet

<table>
<thead>
<tr>
<th>Month</th>
<th>Cu (mg l⁻¹)</th>
<th>Pb (mg l⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>1.29 a,b</td>
<td>1.14</td>
</tr>
<tr>
<td>April</td>
<td>2.07 b</td>
<td>1.1</td>
</tr>
<tr>
<td>June</td>
<td>1.77 b</td>
<td>0.17</td>
</tr>
<tr>
<td>August</td>
<td>1.29 a,b</td>
<td>0.11</td>
</tr>
<tr>
<td>October</td>
<td>1.1 a</td>
<td>0.1</td>
</tr>
<tr>
<td>December</td>
<td>0.94 a</td>
<td>0.09</td>
</tr>
</tbody>
</table>

For a given metal, mean concentrations followed by the same letter (a, b, c) are not significantly different (p<0.05).

Cu: copper, Pb: lead, \( \bar{x} \): mean, SD: standard deviation, Min: minimum, Max: maximum.

Table 3. Concentrations of Cu and Pb in sediment from Bung Boraphet

<table>
<thead>
<tr>
<th>Month</th>
<th>Cu (mg kg⁻¹ dry wt.)</th>
<th>Pb (mg kg⁻¹ dry wt.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February</td>
<td>28.73 a</td>
<td>4.68</td>
</tr>
<tr>
<td>April</td>
<td>30.21 a,b</td>
<td>4.67</td>
</tr>
<tr>
<td>June</td>
<td>41.15 c</td>
<td>11.72</td>
</tr>
<tr>
<td>August</td>
<td>31.38 a,b</td>
<td>4.64</td>
</tr>
<tr>
<td>October</td>
<td>32.16 a,b</td>
<td>4.63</td>
</tr>
<tr>
<td>December</td>
<td>34.89 b</td>
<td>5.31</td>
</tr>
</tbody>
</table>

For a given metal, mean concentrations followed by the same letter (a, b, c) are not significantly different (p<0.05).

Cu: copper, Pb: lead, \( \bar{x} \): mean, SD: standard deviation, Min: minimum, Max: maximum.

Fig. 2. Concentration of Cu (a) and Pb (b) in the water from Bung Boraphet.

Fig. 3. Concentration of Cu (a) and Pb (b) in the sediment from Bung Boraphet.
system[17]. The observed high concentrations of Cu and Pb in this present study are consistent with previous findings[2]. These high Cu and Pb concentrations in the sediment can also cause metal pollution in the swamp.

The concentrations of Cu and Pb in tissues of Corbicula sp. were determined in 10 study sites (Table 4, Fig. 4). The average concentrations of Cu ranged from 12.28 to 13.43 \(\mu\)g g\(^{-1}\) based on the dry weight. A comparison between seasons using a one-way ANOVA test showed no significant seasonal difference (\(p \geq 0.05\)) in the Cu concentration in tissues of clams over a 1 year period. The average concentrations of Pb in Corbicula sp. tissues (dry weight) ranged from 18.04 \(\mu\)g g\(^{-1}\) (in August) to 20.6 \(\mu\)g g\(^{-1}\) (in February).

In this study, the Cu concentrations in the tissues of Corbicula sp. were higher than those reported by Joy et al.[18] for Corbicula fluminea, and mussels (Amblema plicata)[7], but lower than those reported by Verrengia Guerrero and Wider[19], Belanger et al.[20], and Graney et al.[21] for C. fluminea and snails (Potamopyrgus jenkinsi)[22]. The concentrations of Pb in the tissues of Asian clams were higher than the average in reported by Luoma et al.[23] and Verrengia Guerrero and Wider[19], but lower than those observed by Tatem[24].

### 4. Conclusions

This study examined the concentrations of Cu and Pb in water, sediment and Corbicula sp. in Bung Boraphet in Thailand to determine the possible polluting effect of soil erosion and the dissolution of water soluble salts from the Nan River. The water in Bung Boraphet was medium clean according to the surface water quality standards of Thailand. The results of the Cu and Pb concentration assessments in water from Bung Boraphet were compared with those of the drinking water standards. Although the concentrations of Cu and Pb in water from Bung Boraphet were low, heavy metals can accumulate at high levels in the sediment and food chain due to the detection of Cu and Pb in tissues of Corbicula sp. In the near future, management practices and regulator approaches for Cu and Pb contamination in Bung Boraphet will be needed to protect the water resource.

### Acknowledgements

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### References


