ACCUMULATION OF HEAVY METALS IN WATER SPINACH (*IPOMOEA AQUATICA*) CULTIVATED IN THE BANGKOK REGION, THAILAND

AGNETA GÖTHBERG,*† MARIA GREGER,‡ and BENGT-ERIK BENGTSSON†
†Institute of Applied Environmental Research (ITM), Laboratory for Aquatic Environmental Chemistry, Stockholm University, SE-106 91 Stockholm, Sweden
‡ Institution of Botany, Stockholm University, SE-106 91 Stockholm, Sweden

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Abstract—The aquatic plant water spinach (*Ipomoea aquatica*), either wild or cultivated, is found throughout Southeast Asia and is a widely consumed vegetable in the region. Many of the waters where *I. aquatica* grows serve as recipients for domestic and other types of wastewater. Because these waters contain not only nutrients, but also a wide variety of pollutants, including heavy metals, from various human activities, many people risk intoxication. To estimate the accumulation of lead (Pb), cadmium (Cd), total mercury (total Hg), and methylmercury in *I. aquatica* and the potential hazard to human health via consumption, nine sites for cultivation of *I. aquatica* in the greater Bangkok region of Thailand were sampled. At seven of the sites, *I. aquatica* was cultivated for the local food market. The concentrations of methylmercury, total Hg, Pb, and Cd in *I. aquatica* were 0.8 to 221, 12 to 2,590, 40 to 530, and ≤10 to 123 μg/kg dry weight, respectively. At all sites at least one element showed relatively high concentrations and no reference site could be established. From threshold values for highest tolerable intake of these metals by humans and information about consumption of *I. aquatica* among local people, Pb and Cd concentrations in *I. aquatica* do not seem to be a direct threat to human health. However, concentrations of Hg were very high at some sites, and were higher in leaves (highest mean value: 1,440 μg/kg dry wt) than in stems (highest mean value: 422 μg/kg dry wt). This might be a threat, especially to children and fetuses, because Hg in *I. aquatica* was composed of methylmercury, partly or totally, at most sites to 11% or less and at one site from 50 to 100%. At the latter site, *I. aquatica* was not cultivated for the food market. Because other food sources, such as fish, may have high concentrations of methylmercury, these results indicate a need for monitoring of Hg, especially methylmercury, in different foodstuffs in the region.

Keywords—Aquatic macrophytes *Ipomoea aquatica* Heavy metals Mercury Methylmercury

INTRODUCTION

Water spinach (*Ipomoea aquatica* Forsk) is an aquatic vascular plant that occurs both wild and commonly cultivated in Southeast Asia, India, and southern China. Water spinach is confined to the tropics and subtropics and does not grow well where the mean temperature is below 24°C [1]. *Ipomoea aquatica* has two varieties, a land form and a semiaquatic form [2]. The latter, which is studied here, is a herbaceous perennial growing in or near water and wet soils. The long, hollow, and viny stems grow prostrate or floating and roots are produced from the nodes and penetrate into wet soil or mud. The growing tips and young, floating stems (the upper 40–50 cm) with petioles and leaves make a delicious vegetable that is very much appreciated. Water spinach has a high food value and is rich in vitamin A, vitamin C, and iron [2]. Water spinach is easily grown with little labor and grows rapidly up to 10 cm/d [3]. The older parts of the plants are often used for feeding domestic animals and cultivated fish. Water spinach often is cultivated in eutrophic, shallow ponds and canals or in former rice fields that are subject to flooding, and it has a proven ability to control water quality [1,4,5].

In Southeast Asia, more and more waters have become polluted because of a rapid economic development and urbanization, with many people moving from the countryside to big cities. This causes a mixed culture where people try to combine old cultivating methods with the modern expanding urban environment. For this reason, *I. aquatica* is often cultivated and consumed in areas that are quite unsuitable for food production because of pollution. The ditches, ponds, and canals where *I. aquatica* grows serve as recipients for domestic and other types of wastewater. Because these waters contain not only nutrients, but also a wide variety of pollutants, including heavy metals, from various human activities, many people risk intoxication.

The amount of metals taken up in plants differs between species. Different species also accumulate metals to various degrees in different parts of the plant [6–10]. The uptake capacity also varies depending on the metal [6–10]. Several environmental factors affect the bioavailability and uptake of heavy metals by plants in an aquatic environment, including pH, temperature, organic matter, and redox potential [11–13]. Nevertheless, macrophytes reflect the level of bioavailable metal contamination in the environment, and some species of aquatic vascular plants are used for monitoring of the bioavailable fraction of heavy-metal pollution [13,14].

The heavy metals mercury (Hg), cadmium (Cd), and lead (Pb) do not have any essential function but they are detrimental, even in small quantities, to plants, animals, and humans, and accumulate because of a long biological half-life. The detrimental effect of Hg is primarily because of the capacity of inorganic Hg to transform into organic methylmercury, which is the most toxic form [15]. In plants, Pb inhibits growth; Hg stunts seedling growth and root development and inhibits photosynthesis; and Cd interferes with photosynthesis and mineral assimilation with leaf chlorosis, necrosis, and ab...
scission as toxicity symptoms [16]. Human fetuses and small children are especially susceptible to Pb and Hg, which adversely affect the central nervous system, impacting the neurologic, psychomotor, and intellectual development of the child [15]. Cadmium accumulates in the liver and, above all, in the kidneys, where injuries first appear at a more or less old age, depending on the amount that has been accumulated [15]. The World Health Organization has set threshold values for highest tolerable intake by humans of total Hg, methylmercury, Cd, and Pb ([17,18] www.fao.org).

Because *I. aquatica* is cultivated in areas that seem unsuitable for food production because of pollution, and because it is one of the most consumed vegetables in the area, information was needed about accumulated toxic metals. The objectives of this study were to determine the concentrations of Hg, Cd, and Pb in *I. aquatica* that is cultivated for the local food market in Bangkok, Thailand; to compare concentrations of these metals in different subsections of the plants to learn whether not eating a certain part is a way to minimize human exposure to these metals; and to compare the measured metal concentrations in the edible parts of the plants with published highest tolerable intake data for humans.

**MATERIALS AND METHODS**

**Sampling and preparation**

To determine concentrations of Hg, Cd, and Pb in *I. aquatica* that is cultivated in a densely populated urban area, samples of *I. aquatica* were collected in April and May 1999 at nine locations of cultivation spread out in the greater Bangkok region (Fig. 1 and Table 1). *Ipomoea aquatica* was cultivated for the local market at all of these sites, except sites 2 and 9. A sewage treatment experiment with *I. aquatica* was performed at site 2 and water spinach was cultivated for individual households at site 9.

The upper 50 cm of *I. aquatica* is sold in the food market. Therefore, when sampling, that part of *I. aquatica*, in bunches of approximately 10 young stems complete with leaves and petioles, were cut off and used. Three replicates were collected at each site. Back in the laboratory, the plants were first rinsed in tap water to remove particles and loose material attached to their surfaces, then rinsed in 20 mM ethylenediaminetetraacetic acid (EDTA) (a metal-chelating agent) for 10 min to remove any adsorbed metals, and finally rinsed three times in distilled water. This treatment was done to evaluate the metal absorption by the plant. To evaluate if eating only a certain part of *I. aquatica* is a way to minimize exposure to metals, each bunch was then cut into three parts of equal length (16–

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**Table 1. Sites for sampling of water spinach (*Ipomoea aquatica*) in Greater Bangkok, Thailand, April and May 1999**

<table>
<thead>
<tr>
<th>No.</th>
<th>Sampling date, site</th>
<th>Type</th>
<th>Water depth (m)</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>April 22, Ban Khu Salot (15.0°N, 100.26°E)</td>
<td>Rural marshland; former rice field</td>
<td>0.8–1</td>
<td>Plants connected to sediment; fertilizer and pesticides used</td>
</tr>
<tr>
<td>2</td>
<td>April 27, Asian Institute of Technology (14.4°N, 100.37°E)</td>
<td>Campus area; concrete furrow with wastewater</td>
<td>0.10–0.15</td>
<td>Not commercial; no fertilizer or pesticide</td>
</tr>
<tr>
<td>3</td>
<td>April 28, Rangsit (13.59°N, 100.38°E)</td>
<td>Highly populated suburb; canal parallel to highway and heavy traffic; water muddy, flowing</td>
<td>~5–6</td>
<td>No fertilizer or pesticide</td>
</tr>
<tr>
<td>4</td>
<td>April 28, Kassetsart University (13.51°N, 100.35°E)</td>
<td>Campus area; canal with standing and shallow water</td>
<td>1–1.5</td>
<td>Plants connected to sediment; fertilizer and pesticides used</td>
</tr>
<tr>
<td>5</td>
<td>April 28, Kassetsart University</td>
<td>As site 4, but 300 m further up the canal</td>
<td></td>
<td>Fertilizer and pesticides used</td>
</tr>
<tr>
<td>6</td>
<td>April 29, Thaling Chan (13.47°N, 100.26°E)</td>
<td>Suburb; shallow irrigation canals with standing water</td>
<td></td>
<td>Plants connected to sediment; fertilizer and pesticides used</td>
</tr>
<tr>
<td>7</td>
<td>April 29, Sampran (13.45°N, 100.14°E)</td>
<td>Tha Chin River; muddy, fast flowing, strong currents</td>
<td>~10</td>
<td>Fertilizer and pesticides used</td>
</tr>
<tr>
<td>8</td>
<td>April 29, Nakhor Chaisri (13.48°N, 100.12°E)</td>
<td>As site 7, but ~10 km upstream; a large wine and liquor distillery &lt;1 km upstream</td>
<td></td>
<td>Fertilizer and pesticides used</td>
</tr>
<tr>
<td>9</td>
<td>May 4, Bang Yai (13.51°N, 100.26°E)</td>
<td>Highly populated suburb; people living on the canal; water slowly flowing</td>
<td>2–3</td>
<td>Not commercial; no fertilizer or pesticide</td>
</tr>
</tbody>
</table>
analysed with gas chromatography–cold-vapor atomic fluorescence spectroscopy, with a detection limit of 0.06 µg/kg [19]. Samples of stems and leaves were analysed for total Hg with flameless atomic absorption (FAA) according to Swedish Standardization Organization FAA method SS028175 [20]. The samples from the Asian food store also were analysed for total Hg with FAA method SS028175 [20] and for Cd and Pb as for the other samples.

**Statistics**

Metal concentrations at different sites were compared. The top sample replicates from each site were compared with the top sample replicates from the other sites, and the middle and bottom sample replicates were compared in the same way. This was done by using one-way analysis of variance and the Tukey honestly significant difference post hoc test or, if unequal variances of means, the Games Howell post hoc test. Metal concentrations in the different parts of the plants from each site, top, middle, and bottom were compared with t tests. Replicates were compared, top with middle, top with bottom, and middle with bottom. The concentrations of total Hg in stems and leaves were also compared with t tests.

**RESULTS AND DISCUSSION**

A wide range occurred between lowest and highest concentrations of methylmercury, total Hg, Pb, and Cd, respectively, in *Ipomoea aquatica*, that is, 0.8 to 221, 12 to 2,590, 40 to 530, and ≤10 to 123 µg/kg dry weight. At least one element demonstrated more or less high concentrations at all sites and no reference site could be established. Lead concentrations were high (*p* < 0.05) at site 2 (compared to sites 1, 3, 4, 5, 7, and 8 in the middle part of plants; Table 2). Cadmium concentrations were high (*p* < 0.05) at site 1 (compared to sites 2, 3, 4, and 5 in the middle part of plants) and at site 9 (compared to sites 2 and 4 in the top part of plants; Table 3). Total Hg concentrations were high (*p* < 0.05) at site 2 (compared to sites 1, 3, 5, 6, 7, and 9 in the top part; compared to sites 3 and 9 in the middle part; and compared to sites 1, 3, 7, and 9 in the bottom part of plants), at site 4 (compared to sites 3, 5, 7, and 9 in the top part of plants), and at site 8 (compared to site 9 in the top part and sites 3 and 9 in the middle part of plants; Table 4). Because only one sample from

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**Table 2. Lead concentrations (µg/kg dry wt) in water spinach (*Ipomoea aquatica*) from Bangkok, Thailand (n = 3 ± standard error)**

<table>
<thead>
<tr>
<th>Site</th>
<th>Top</th>
<th>Middle</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>93 ± 12</td>
<td>123 ± 28</td>
<td>133 ± 3</td>
</tr>
<tr>
<td>2</td>
<td>180 ± 47</td>
<td>353 ± 81</td>
<td>263 ± 52</td>
</tr>
<tr>
<td>3</td>
<td>80 ± 6</td>
<td>90 ± 15</td>
<td>123 ± 23</td>
</tr>
<tr>
<td>4</td>
<td>70 ± 20</td>
<td>80 ± 15</td>
<td>130 ± 23</td>
</tr>
<tr>
<td>5</td>
<td>73 ± 28</td>
<td>107 ± 26</td>
<td>227 ± 122</td>
</tr>
<tr>
<td>6</td>
<td>280 ± 125</td>
<td>193 ± 32</td>
<td>140 ± 11</td>
</tr>
<tr>
<td>7</td>
<td>120 ± 21</td>
<td>147 ± 45</td>
<td>160 ± 36</td>
</tr>
<tr>
<td>8</td>
<td>117 ± 15</td>
<td>150 ± 23</td>
<td>170 ± 6</td>
</tr>
<tr>
<td>9</td>
<td>180 ± 17</td>
<td>200 ± 26</td>
<td>290 ± 73</td>
</tr>
</tbody>
</table>

**Table 3. Cadmium concentrations (µg/kg dry wt) in water spinach (*Ipomoea aquatica*) from Bangkok, Thailand (n = 3 ± standard error)**

<table>
<thead>
<tr>
<th>Site</th>
<th>Top</th>
<th>Middle</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40 ± 5</td>
<td>24 ± 1</td>
<td>28 ± 5</td>
</tr>
<tr>
<td>2</td>
<td>12 ± 1</td>
<td>12 ± 2</td>
<td>15 ± 3</td>
</tr>
<tr>
<td>3</td>
<td>20 ± 5</td>
<td>10 ± 0</td>
<td>20 ± 6</td>
</tr>
<tr>
<td>4</td>
<td>12 ± 2</td>
<td>11 ± 1</td>
<td>11 ± 1</td>
</tr>
<tr>
<td>5</td>
<td>14 ± 3</td>
<td>11 ± 1</td>
<td>11 ± 1</td>
</tr>
<tr>
<td>6</td>
<td>25 ± 3</td>
<td>26 ± 7</td>
<td>53 ± 18</td>
</tr>
<tr>
<td>7</td>
<td>14 ± 2</td>
<td>14 ± 2</td>
<td>12 ± 0</td>
</tr>
<tr>
<td>8</td>
<td>60 ± 31</td>
<td>30 ± 11</td>
<td>50 ± 36</td>
</tr>
<tr>
<td>9</td>
<td>30 ± 1</td>
<td>39 ± 10</td>
<td>32 ± 4</td>
</tr>
</tbody>
</table>

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17 cm). These samples are called top, middle, and bottom and they all consist of stems, leaves, and petioles, but no roots (Fig. 2).

As a complementary study, extra plant material was sampled after another 9 d at sites 1, 2, and 9. These plant bunches were not divided into three parts, but stems and leaves were separated and four replicate samples were prepared from each station. This was done to study a potentially higher concentration of total Hg in the leaves compared to in the stems.

Because this study deals, in part, with possible human intake of metals via *Ipomoea aquatica*, the effect of the rinsing procedure described above was compared to merely rinsing in tap water. For that purpose, two bunches of imported fresh *Ipomoea aquatica* were bought in an Asian food store in Stockholm, Sweden. One half of each bunch was rinsed in the same manner as described above and the other half was rinsed only in tap water, as would probably be done in a home.

**Analyses**

The samples were dried in 45°C for 7 d, ground in an agate mortar, and digested in concentrated HNO₃, (analytical grade) that had been purified by subboiling distillation in a quartz apparatus. Three replicates of top, middle, and bottom samples from each site were analysed for total Hg with cold-vapor atomic fluorescence spectroscopy according to the European standard method (EN13506), and for Cd and Pb with inductively coupled plasma mass spectrometry. The analytical methods are accredited by the Swedish Board for Accreditation and Conformity Assessment and analyses were performed with continuous monitoring on a standard reference material, NBS 1571 (National Bureau of Standards, Washington, DC, USA). Detection limits for the methods are 10 µg/kg of total Hg, Cd, and Pb. Depending on amount of sample left after total Hg, Cd, and Pb analyses, one replicate was chosen of either a top, medium, or bottom sample from each site (three samples from site 2) for analysis of methylmercury. Methylmercury was analyzed with gas chromatography–cold-vapor atomic fluorescence spectroscopy, with a detection limit of 0.06 µg/kg [19]. Samples of stems and leaves were analysed for total Hg with flameless atomic absorption (FAA) according to Swedish Standardization Organization FAA method SS028175 [20]. The samples from the Asian food store also were analysed for
Accumulation of heavy metals in water spinach

Table 4. Concentrations of total mercury (µg/kg dry wt) in water spinach (Ipomoea aquatica) from Bangkok, Thailand (n = 3 ± standard error)

<table>
<thead>
<tr>
<th>Site</th>
<th>Top</th>
<th>Middle</th>
<th>Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>81 ± 16</td>
<td>95 ± 12</td>
<td>88 ± 13</td>
</tr>
<tr>
<td>2</td>
<td>207 ± 29</td>
<td>195 ± 17</td>
<td>187 ± 10</td>
</tr>
<tr>
<td>3</td>
<td>47 ± 11</td>
<td>37 ± 7</td>
<td>41 ± 5</td>
</tr>
<tr>
<td>4</td>
<td>167 ± 41</td>
<td>166 ± 82</td>
<td>92 ± 29</td>
</tr>
<tr>
<td>5</td>
<td>44 ± 19</td>
<td>75 ± 25</td>
<td>72 ± 24</td>
</tr>
<tr>
<td>6</td>
<td>77 ± 8</td>
<td>68 ± 9</td>
<td>74 ± 16</td>
</tr>
<tr>
<td>7</td>
<td>56 ± 2</td>
<td>39 ± 3</td>
<td>34 ± 4</td>
</tr>
<tr>
<td>8</td>
<td>130 ± 21</td>
<td>178 ± 17</td>
<td>228 ± 63</td>
</tr>
<tr>
<td>9</td>
<td>27 ± 10</td>
<td>27 ± 7</td>
<td>34 ± 5</td>
</tr>
</tbody>
</table>

Table 5. Total mercury (Hg) and methylmercury, (µg/kg dry wt) in water spinach (Ipomoea aquatica) from Bangkok, Thailand (n = 1)

<table>
<thead>
<tr>
<th>Site</th>
<th>Type of sample</th>
<th>Total Hg</th>
<th>Methylmercury</th>
<th>Methylmercury % of total Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bottom</td>
<td>95</td>
<td>10.5</td>
<td>11.0</td>
</tr>
<tr>
<td>2</td>
<td>Middle</td>
<td>185</td>
<td>96.5</td>
<td>52.0</td>
</tr>
<tr>
<td>2</td>
<td>Top</td>
<td>257</td>
<td>201.0</td>
<td>78.0</td>
</tr>
<tr>
<td>2</td>
<td>Top</td>
<td>211</td>
<td>221.0</td>
<td>104.0</td>
</tr>
<tr>
<td>3</td>
<td>Bottom</td>
<td>44</td>
<td>1.1</td>
<td>2.5</td>
</tr>
<tr>
<td>4</td>
<td>Bottom</td>
<td>35</td>
<td>2.4</td>
<td>6.7</td>
</tr>
<tr>
<td>5</td>
<td>Bottom</td>
<td>106</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>6</td>
<td>Bottom</td>
<td>43</td>
<td>1.1</td>
<td>2.6</td>
</tr>
<tr>
<td>7</td>
<td>Bottom</td>
<td>29</td>
<td>1.2</td>
<td>4.2</td>
</tr>
<tr>
<td>8</td>
<td>Bottom</td>
<td>182</td>
<td>1.2</td>
<td>0.7</td>
</tr>
<tr>
<td>9</td>
<td>Top</td>
<td>46</td>
<td>0.8</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Table 6. Concentrations of total mercury (µg/kg dry wt) in leaves and stems of water spinach (Ipomoea aquatica) from Bangkok, Thailand, 1999 (n = 4 ± standard error)

<table>
<thead>
<tr>
<th>Site</th>
<th>Sampling date</th>
<th>Leaves</th>
<th>Stems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>May 3</td>
<td>62 ± 1</td>
<td>44 ± 2</td>
</tr>
<tr>
<td>2</td>
<td>May 6</td>
<td>276 ± 14</td>
<td>143 ± 27</td>
</tr>
<tr>
<td>9</td>
<td>May 13</td>
<td>1,440 ± 386</td>
<td>422 ± 191</td>
</tr>
</tbody>
</table>

weight in leaves and stems, respectively. The variation in Hg concentrations between the two sampling occasions at site 9 is large and indicates a need for more thorough studies.

Concentrations of Hg, Cd, and Pb in aquatic vascular plants collected in other tropical freshwater ecosystems have been reported [10,27–34]. In those investigations, Pb concentrations in shoots varied from 1,600 to 51,000, total Hg concentrations varied from 10 to 950, and Cd concentrations varied from 50 to 4,200 µg/kg dry weight. Compared to the present study of metals in I. aquatica, Pb concentrations reported elsewhere are about 10 to 100 times higher [10,28–33], total Hg concentrations are in the same range [26–28,32,34] and Cd concentrations vary from the same range to about 100 times higher in other studies [10,28–30,32].

In the different parts of the plants, Pb concentrations mostly decreased from bottom to top (not at site 6). However, this pattern was significant only in plants at sites 1 and 8 (p < 0.05; Table 2). Total Hg concentrations increased from bottom to top in some sites, significantly so in plants at site 7 (p < 0.05; Table 4). The proportion of leaves is highest in the top samples and smallest in the bottom samples and the concentrations of total Hg in the leaves were higher, significantly so at sites 1 and 2 (p < 0.05), than in the stems of the same specimens (Table 6). This trend is in concordance with findings in other investigations, where I. aquatica and Eichornia crassipes exposed to elevated Hg concentrations in the water accumulated higher concentrations of Hg in the leaves than in the stems [27,34]. Finally, the Cd concentrations were similar in different parts of the plants (Table 3). The trend for Pb leads to the recommendation to avoid eating the bottom part of I. aquatica, the trend for Hg leads to the recommendation to avoid eating the leaves, and for Cd no such recommendation may be given.

To compare the metal levels in the cultivated I. aquatica obtained in this study with the highest tolerable intake of Pb, Hg, and Cd according to the World Health Organization [17,18], the metal data for I. aquatica were recalculated to fresh weight. Based on this calculation, the highest recommended consumption of I. aquatica regarding Pb would be 12 kg fresh weight per day for adults and 2 kg per day for children. Regarding Cd, the highest recommended consumption would be 7.5 kg and 2.5 kg per day for adults and children, respectively. Concerning total Hg and Hg in the form of methyl mercury, a recommended highest intake is given only for adults. Data are considered too incomplete to recommend a highest tolerable intake for pregnant women and children, which is why they are recommended to avoid food that might contain elevated concentrations. However, a Dutch document suggests 40 µg as a guideline for highest weekly intake of methyl mercury by pregnant women and small children [35]. Thus, calculated based on the highest analyzed concentration of methyl mercury in this investigation, the highest recommended consumption of I. aquatica for adults would be 2.0 kg/d and for children and pregnant women it would be 0.4 kg/
In the Bangkok area 557 households of local people have been interviewed regarding their consumption of *I. aquatica* (A.A. Mon, Asian Institute of Technology, Bangkok, Thailand, and M. Wallin, Gothenburg University, Göteborg, Sweden, unpublished data). The highest individual consumption was 0.36 kg/d, which is close to the highest recommended consumption of *I. aquatica* by pregnant women and children regarding methylmercury.

The usual way to treat vegetables before cooking is rinsing in tap water. Rinsing with the metal-binding chelator EDTA compared to rinsing in only tap water showed a mean reduction of Pb concentrations of 29% when plants were rinsed in EDTA, but no reduction of Hg and Cd concentrations (Fig. 3). This means that, because of the EDTA rinsing, the analyzed Pb concentrations in the Bangkok plants may represent a minimum, that is, only Pb that is absorbed in the plant and not attached to the surface.

From the calculated highest recommended consumption of *I. aquatica* in this study, and from the results of the investigation of consumption of *I. aquatica* among local people, Pb and Cd concentrations in this investigation do not seem to be a direct threat to human health. However, reason exists to be aware of possible additional routes of these metals to children’s food, and, regarding Pb, it is preferable to avoid the bottom aware of possible additional routes of these metals to children’s food. The use of stems rather than leaves in cooking is recommended. Additional food sources, such as fish, where the Hg is more attached to the surface.

From the calculated highest recommended consumption of *I. aquatica* in this study, and from the results of the investigation of consumption of *I. aquatica* among local people, Pb and Cd concentrations in this investigation do not seem to be a direct threat to human health. However, reason exists to be aware of possible additional routes of these metals to children’s food, and, regarding Pb, it is preferable to avoid the bottom part of *I. aquatica*. However, Hg might be a threat, in particular to children and fetuses, and especially because Hg in *I. aquatica* obviously can be made up by totally or partly methylmercury. A tendency exists toward higher Hg concentrations in the top samples, because of a great proportion of leaves with higher Hg concentrations than in the stems, which is why the use of stems rather than leaves in cooking is recommended. Additional food sources, such as fish, where the Hg is more or less totally in the form of methylmercury [36,37], may have high concentrations of methylmercury. These circumstances indicate a need for monitoring of Hg, especially methylmercury, in different foodstuffs in this region.

Acknowledgements—We thank Kwei Lin and Preeda Parkpian at the Asian Institute of Technology for their contributions to this study. We also thank Karin Karlsson for carrying through the sampling and Karin Holm and Pia Kärrehage, Institute of Applied Environmental Research at Stockholm University, for chemical analyses. The study was supported by Swedish International Development Cooperation Agency.

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