Lead and Cadmium Contents in *Ipomoea aquatica* Forsk. Grown in Laguna de Bay

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**INTRODUCTION**

*Ipomoea aquatica* Forsk., locally known as “kangkong” or water spinach, is a herbaceous perennial trailing vine. It has hollow stems that grow floating or prostrate. The roots from the nodes penetrate the soil or mud, and the leaves are simple and alternate. This plant species grows well as a crop in regions where the mean temperature is above 25°C (Patnaik 1976). Hence, the Philippines is a conducive environment for water spinach to flourish. The common variety of the water spinach found in the Philippines which is studied here, grows in water. Its rapid form of reproduction is asexually through vegetative fragmentation. Roots that are formed from the nodes grow into independent plants when separated and carried by water, animals, and man, and become established easily in new places (Patnaik 1976).

The young stems and leaves particularly the upper 30-40 cm which are used as vegetable are good sources of minerals like iron, and vitamins A, C, and E (National Academy of Sciences 1976). Other uses of this plant species include: feeds for livestock, purgatives, diuretics, treatment for gastric and intestinal disorder, and water quality regulator (National Academy of Sciences 1976; Abe et al. 1992).

Laguna de Bay, one of the most vital inland bodies of water in the Philippines, lies at 14°10'-14°35’N, 121°-121°30’E (www.ilec.or.jp/eg/lbmi/reports/15_Laguna_de_Bay_27February2006). The province of Laguna bounds it from the south, Rizal to the north, Batangas, Cavite, and Metro Manila in the west, and Quezon in the...
east. More than 100 hectares of water spinach that grow luxuriantly in this body of water provide for the supply in the major markets in Metro Manila and surrounding provinces. Rapid industrialization, urbanization, population growth, and increasing resource utilization account for the pollution of this lake. One of the most common water pollutants is the heavy metals such as lead (Pb) and cadmium (Cd), that are non-essential and toxic in low concentrations. It has been demonstrated that plants can absorb and accumulate metals in their tissues (Simmons & Tobbins 1995; Fritioff & Greger 2003; Ingole & Bhole 2003). Excess Pb and Cd in plants inhibit photosynthesis, growth, upset mineral nutrition and water balance, cause leaf chlorosis, necrosis, and abscission (Sharma & Dubey 2005; Pais & Jones 1997). Animals and humans that ingest contaminated plants in turn obtain the metals.

A slight increase from the maximum tolerable intake by man set by the World Health Organization can have dangerous effects on human health. Pb toxicity includes negative impacts on the central nervous system, kidneys, and bones. Cd that accumulates in the liver and kidneys damages these organs as well as the central nervous system, immune system, bones, and may even cause cancer.

Since water spinach, which is one of the cheapest vegetable and staple food that make up the normal Filipino diet, is grown and harvested from contaminated freshwaters like Laguna de Bay, there is a need to monitor the concentrations of the heavy metals in this plant. This study was conducted to assess the Pb and Cd concentrations in *Ipomoea aquatica* Forsk. grown in Laguna de Bay, particularly the metal concentrations in the top, middle, and bottom subsections of the upper 36cm of the edible portion of the plants, in the roots, stems, and leaves. Also, the Pb and Cd concentrations in the edible parts of the plants were compared with the maximum tolerable daily intake for humans recommended by WHO. The data in this study may provide information on the following: safety of the water spinach from Laguna de Bay for human consumption, and the specific parts of the plants that should not be eaten to reduce exposure to Pb and Cd.

**MATERIALS AND METHODS**

**Collection and preparation of plant materials**

Samples of *Ipomoea aquatica* Forsk. were collected from three sites around the northern west bay at the border of Agono and Taytay, Rizal in August and September 2005. The staffs of Laguna Lake Development Authority recommended these areas for sampling since water spinach are most abundant in these areas. The three collection sites were classified as follows: site 1(S1) as relatively undisturbed area, situated far from factories and residential houses; site 2 (S2) as industrial area, near factories; and site 3 (S3) as domestic area, situated near residential houses.

Approximately 1kg (whole plants) of water spinach was collected randomly from each site, placed in plastic bags and stored in coolers for transportation to the laboratory. Back in the laboratory, plants were rinsed once with tap water and then twice with distilled water. The upper 36cm from the shoot apex were measured and cut off. These plant portions were then cut into top, middle, and bottom subsections (12cm each with 3 replicates) consisted of vertical stems and leaves with petioles , but no roots and horizontal stems. For the remaining harvested plants, the leaves, vertical and horizontal stems, and roots were segregated. All the different sections and organs were blotted dry with paper towel before obtaining their fresh weights using top loading balance. Then, plants were wrapped in aluminum foil with proper labels, and oven-dried at 80°C until constant weight. The dry weights were also determined.

**Metal analysis in plant tissues**

One (1) gram of each dried ground samples was placed in each crucible and then ashed in a furnace at 500°C for 8 hr. After cooling, the ashes were digested with diluted HNO₃, and then returned to the furnace after the evaporation of excess HNO₃. Diluted HCl was then added and heated on a hot plate until the solid particles were dissolved. The filtered samples were then diluted to final volume of 25 ml. Three replicates of the different subsections and organs from each site were analyzed for Pb and Cd concentrations using the atomic absorption spectrophotometry (AOAC 1990).

**Statistical analysis**

The data obtained were subjected to statistical analysis using one- way analysis of variance (ANOVA) and Tukey test.
the plants from sites 1 and 2 with undetected Pb in the different plant organs (Table 1). The roots and the vertical stems of plants from site 3 had significantly higher Pb concentrations than the horizontal stems and leaves. The sequence of Pb concentrations in the different organs of the plants were as follows: roots ≥ vertical stems ≥ horizontal stems ≥ leaves. The following ratios between the different organs and roots were noted: 0.82 vertical stem/root; 0.60 horizontal stem/root and 0.36 leaf/root. It is evident in these ratios that the highest Pb concentration was translocated from the roots to the vertical stems and the lowest Pb translocation was to the leaves. There was a decreasing trend of Pb concentration from roots to the leaves. The general view is that all freshwater macrophytes obtain nutrients and other elements through their roots from the sediments in which they grow (Jackson 1998). Hence, the highest Pb concentration was found in the leaves. Moreover, the uptake of Pb through direct contact of the roots and the stems with the contaminated water have contributed to the increase of the metal in the roots and stems than in the leaves that were not in contact with the water. The highest concentration of Pb noted in the roots and lowest translocation of Pb to the leaves may also be attributed to the absorbed Pb being mostly bound to the cell wall of roots as shown in previous studies (Fritioff and Greger 2006; Soltan and Rashed 2003).

In the edible subsections of upper 36 cm (top, middle, and bottom), only the bottom subsections from site 3 showed Pb accumulations of 0.259±0.45 mg/kg DW compared to the top and middle. However, the three subsections from site 3 were not statistically different. A similar trend was observed in the study conducted by Göthberg et al. (2002), where the Pb concentrations mostly decreased from bottom to top parts of the upper 50cm of Ipomoea aquatica Forsk collected from Bangkok, Thailand. In the present study, the Pb concentrations in the bottom section of the edible portion of the plant may be attributed to the Pb accumulation in the vertical stems since higher Pb concentration was noted in the vertical stems than in the leaves. Also, the vertical stems constituted the greater portions of the bottom sections of the edible parts of the plants. The possible sources of Pb in site 3 which is situated near the residential area are domestic wastes, wastes from fishing, boating, and other human activities. Containers of paint, old metal cages, car batteries and fishing weights were observed in this area of the lake. It could also be due to the presence of a nearby metal alloy factory found in site 2 that releases Pb in the air and water which are carried by the wind and water currents to accumulate in site 3. Lead monoxide (PbO), lead dioxide (PbO₂), red lead (Pb₃O₄) and lead chromate (PbCrO₄) are examples of Pb compounds released in the environment.

The Pb concentration of 0.259 mg/kg DW in the bottom subsection was recalculated to fresh weight (FW) that is equivalent to 0.027 mg/kg FW. Comparing this data, 0.027 mg/kg FW, with the maximum tolerable daily intake of Pb for a 60kg man set by the WHO (2001), which is 0.21 mg/kg FW, Pb concentration was found to be far below the standard. Based on the calculations, the highest recommended consumption of water spinach regarding Pb for a 60kg man would be 7.92 kg per day. Hence, the Pb concentration in water spinach does not pose a threat to human health.

To minimize Pb intake, it is recommended that the bottom part (lower 12 cm of the upper 36 cm from the shoot apex) of the plant should be removed. Due to the decreasing trend for Pb from bottom to top, Göthberg et al. (2002) had similarly recommended to avoid eating the bottom part.

Although there was no significant differences in the Cd concentrations in the different organs of the plants collected from the three sites in Laguna de Bay, the plants collected from site 2 had Cd accumulations in the roots, horizontal stems, and leaves; from site 3 in the roots and leaves; and from site 1 in the vertical stems (Table 2).

### Table 1. Lead (Pb) concentrations in the different organs of Ipomoea aquatica Forsk. collected from three sites in Laguna de Bay

<table>
<thead>
<tr>
<th>Sites</th>
<th>Leaves</th>
<th>Vertical Stems</th>
<th>Horizontal Stems</th>
<th>Roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S2</td>
<td>0.006±0.01</td>
<td>0</td>
<td>0.006±0.01</td>
<td>0.047±0.05</td>
</tr>
<tr>
<td>S3</td>
<td>0.016±0.03</td>
<td>0</td>
<td>0.016±0.03</td>
<td>0</td>
</tr>
</tbody>
</table>

Mean data of n=3 ± standard error

### Table 2. Cadmium (Cd) concentrations in the different organs of Ipomoea aquatica Forsk. collected from the three sites in Laguna de Bay

<table>
<thead>
<tr>
<th>Sites</th>
<th>Leaves</th>
<th>Vertical Stems</th>
<th>Horizontal Stems</th>
<th>Roots</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0.045±0.08</td>
<td>0.006±0.01</td>
<td>0.047±0.05</td>
<td>0</td>
</tr>
<tr>
<td>S2</td>
<td>0.016±0.03</td>
<td>0</td>
<td>0.016±0.03</td>
<td>0</td>
</tr>
</tbody>
</table>

Mean data of n=3 ± standard error
The top and bottom subsections of the edible parts of the water spinach collected from site 2 were found to have Cd accumulations of 0.0058±0.01 mg/kg DW and 0.0054±0.009 mg/kg DW, respectively. Cd was not detected in the subsections of the upper portions of the plants from sites 1 and 3. However, the Cd concentrations did not vary significantly in the top, middle, and bottom portions of the plants collected from the three sites. This result is in agreement with the findings of Göthberg et al. (2002), where Cd concentrations were similar in the different parts of water spinach cultivated in Bangkok, Thailand. The Cd concentrations in the top and bottom portions of the upper 36 cm from the shoot apex of the plants may be found in the leaves than in the vertical stems. Cd concentrations were noted only in the leaves and not in the vertical stems of plants collected from site 2 (Table 2). A nearby metal alloy factory in site 2 may have contributed to the Cd contamination of the water and Ipomoea aquatica Forsk. plants. Other possible sources of Cd that were found in the lake are batteries, ceramics, and paint in plastic containers and glasses.

The Cd concentrations in the top and bottom portions of the edible parts expressed in dry weights were converted to fresh weights that are equivalent to 0.0006 and 0.0005 mg Cd/kg FW, respectively. Comparing these values with the maximum tolerable daily intake set by the WHO (2001) for a 60 kg man, that is 0.06 mg/kg FW, the Cd concentrations in the water spinach were far below the standards. Thus, the Cd level is non-toxic to man. Based on the computations, a 60 kg man should eat about 100–120 kg per day of water spinach to reach the highest recommended daily intake for Cd, that is far from the normal eating capacity of a person per day.

In conclusion, the Pb and Cd concentrations of the Ipomoea aquatica Forsk. plants grown in Laguna de Bay are not hazardous to human health. However, to minimize Pb intake, the bottom part of the plant should be removed. There is also a need to monitor other heavy metals like mercury (Hg) and chromium (Cr) in water spinach and in other foodstuffs like fish that are obtained from Laguna de Bay.

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