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LEVELS OF LEAD IN SELECTED COMMON MEDICINAL PLANTS GROWING ALONG ROADSIDE IN LEYTE

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ABSTRACT

Lead, as an important environmental pollutant from vehicular emission, is generally the largest source of heavy metal contamination in roadside ecosystems. Ten common Philippine medicinal plants namely: *Allium fistulosum, Artemisia vulgaris, Basella alba, Ipomoea batatas, Euphorbia hirta, Plectranthus amboinicus, Mimosa pudica, Cymbopogon citratus, Portulaca oleracea,* and *Curcuma longa* growing along the 45-km stretch of the Baybay – Ormoc national highway were investigated for Pb accumulation. The study showed *Curcuma longa, Plectranthus amboinicus,* and *Artemisia vulgaris* had the highest Pb content in the leaves. In the stem, *Mimosa pudica* had the lowest with 5.0 mg/kg while *Plectranthu samboinicus* had the highest with 9.5 mg/kg. In the roots, Pb was highest (18.0 mg/kg) in *Allium fistulosum* but low (below 10.0 mg/kg) in all the other species. Results imply that consumption of medicinal plants growing along busy roads may not be safe, especially those species that accumulate high levels of Pb. Long term usage of these plants may cause serious health problems.

Key words: medicinal plant, lead bioaccumulation, permissible limit, health problems

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INTRODUCTION

Herbal medicines have long been used by Chinese and Western cultures. Today, many drugs are still extracted as fractionate/isolate compounds from raw herbs and purified to meet pharmaceuticals standards (Ahmad and Othman, 2013). Usage of plant materials as a source of medicine for a wide variety of human ailments has increased significantly in the developing nations. Population rise, inadequate supply of drugs, prohibitive cost of treatments, side effects of synthetic drugs and development of resistance to currently used drugs for infectious diseases are some of the reasons why people are switching to medicinal plants (Zahid, 2016).

However, these medicinal plants might grow on soil contaminated with heavy metals from industrial activity, automobile exhaust, municipal wastes, refuse burning and pesticides used in agriculture (Annan et al., 2010). Traffic-associated environmental pollution is one of the most critical or challenging sources, because it is a non-point source and vehicular emissions spread beyond the expected distances polluting the air, land and water bodies (Osakwe and Okolie, 2015).

Plants are the main link in the transfer of heavy metals from contaminated soil to the human body (Ali Khan et al., 2015). Heavy metals like lead enters the plant via root uptake and foliar adsorption. They accumulate over time in the tissues of plants which eventually enter humans through consumption of plant parts and extracts (Kulhari et al., 2013). Consumption of medicinal plants grown in polluted sites is a serious threat to human health.

Ali and Nasralla (1985) suggested that lead accumulates in plants through both foliage and root system, but lead absorption through foliage is more pronounced in locations close to the emission source of lead vapor and fine particles. Sharma and Dubey (2005) reported that plants growing near highways are usually exposed to more lead than in other areas. Ali and Nasralla (1985) reported that vegetables grown adjacent to the busiest streets had elevated levels of Pb in the leaves and roots. Rolli et al. (2015) found that the soil, grass and *Caesalpinia* leaves collected from roadsides likewise contained higher levels of lead. This is because lead compounds are major pollutants present in vehicular exhaust.

In India and some African countries where most people use medicinal plants for the treatment of a wide range of health-related applications, some studies were done to investigate the potential accumulation of lead and other heavy metals in medicinal plants. Deka et al. (2011), discovered that the amount of Pb in the 21 medicinal species they studied exceeded the maximum permissible level (MPL) of Pb in their tissues.

The safety of using medicinal plants grown along highways and well-travelled roads has become a growing concern especially in highly populated areas. Thus, this study was conducted to determine and compare the amounts of lead absorbed by common Philippine medicinal plants growing along potentially lead-contaminated roadsides and to identify which medicinal plant species can tolerate the highest level of lead in their tissues.

MATERIALS AND METHODS

Study Area

Samples of medicinal plants commonly used in the province of Leyte were collected along the Baybay – Ormoc highway. Baybay City and Ormoc City are component cities located on the western coast of the Leyte Province. Figure 1 shows the map of the Leyte Province.

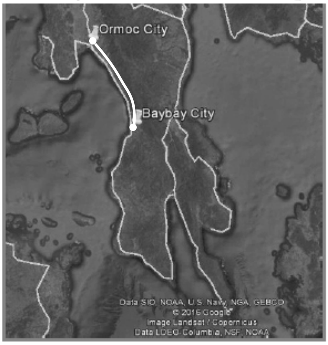

Figure 1.Map of the Leyte Province showing the Baybay – Ormoc Highway

Collection and Preparation of Plant Samples

Five healthy sample plants of each of species were collected. Only those that were growing within a 3-m distance from the edge of the road were included. The sample plants were placed in clean properly-labeled plastic bags and were transported right away to the laboratory for processing. These were washed thoroughly to remove dirt and pat-dried using tissue paper. Each sample was separated into roots, stems and leaves, placed inside separate brown paper bags and dried in an oven at 70^0C for 48 hours. The oven-dried plants were ground into fine powder and analyzed for total Pb using the method of Mylavarapu and Kennelley (2002) at the Central Analytical Services Laboratory (CASL), Visayas State University, Baybay City, Leyte.

Soil Sample Collection

Soil samples were collected from the sites where the top three medicinal plants with the highest lead content were collected. Samples were collected within the immediate vicinity of the plants at a depth of 0-10 cm from the surface. The samples were transferred into labeled plastic bags and analyzed at the Central Analytical Services Laboratory (CASL) for total Pb, pH and organic matter. Total soil Pb content was analyzed using the AquaRegia Method (DIN ISO 11466, 1994).

RESULTS AND DISCUSSION

Description of Study Area

Ormoc City is considered as the economic, cultural, commercial and transportation hub of western Leyte. The highway is busy with motorized vehicles. There are four industrial plants located along this highway, a copra oil milling facility adjacent to an abaca pulp milling facility operated by the Specialty Pulp Manufacturing, Inc.(SPMI) in Brgy. Hilapnitan, Baybay City, an oil mill by SC Global Coco Products, Inc. in Brgy. Caridad, Baybay City, and a carbon processing plant operated by Green Carbon, Inc. in Brgy. Maybog, Baybay City, Leyte.

The major terminals in both cities serve routes from Tacloban City, Maasin City, Metro Manila, Davao City and some other major towns in Leyte, Southern Leyte, and Samar provinces. With the increase in population and industries between the two cities, there is a continuing increase in vehicular volume going to and from Baybay to Ormoc. As a result, there is an increase in vehicular exhaust along this major highway and lead toxicity may occur along this part of the province.

Collected Medicinal Plants

Ten selected medicinal plants growing along the Baybay – Ormoc highway; namely, *Allium fistulosum, Artemisia vulgaris, Basella alba, Curcuma longa, Cymbopogon citratus, Euphorbia hirta, Ipomoea batatas, Mimosa pudica, Plectranthus amboinicus* and *Portulaca oleracea* were collected. These species are among the most commonly used medicinal plants in Leyte.

The ten medicinal plants used are presented in Table 1. The acceptable level of lead in the body as defined by WHO (2007) is 10mg/kg but this amount can already have an adverse effect to the human body. Lead concentration varies per species and in each plant part.

According to Olowu et al. (2015), the uptake and distribution of trace metals vary from species to species and could be associated with the differences in the ability of the plant to control the movement of trace metals from xylem to phloem and via the phloem to other parts of the plant. Table 2 summarizes the pharmacognostic features of the selected medicinal plants.

Table 1. The ten medicinal plants used in the study

SCIENTIFIC NAME	ENGLISH NAME	LOCAL NAME	FAMILY NAME
Allium fistulosum L.	Spring onion	Sibuyas dahon	Amaryllidaceae
Artemisia vulgaris L.	Mugwort	Hilbas Damong maria	Asteraceae
Basella alba L.	Spinach vine	Alugbati	Basellaceae
Curcuma longa L.	Turmeric	Duwaw	Zingiberaceae
Cymbopogon citratus (DC.) Staph	Lemon grass	Tanglad	Poaceae
Euphorbia hirta L.	Asthma weed	Tawa -tawa Gatas -gatas	Euphorbiaceae
Ipomoea batatas (L.) Lam.	Sweet potato	Kamote	Convulvolaceae
Mimosa pudica L.	Sensitive plant	Makahia	Fabaceae
Plectranthus amboinicus L.	Oregano	Carabo Oregano	Lamiaceae
Portulaca oleracea L.	Pigweed, Purslane	Olasiman	Portulacaceae

Table 2. Pharmacognostic features of the ten medicinal plants studied

SCIENTIFIC NAME	REFERENCE	PARTS UTILIZED	MEDICINAL USE
Allium fistulosum L.	Fern (2014)	Leaves, bulb	For treatment of colds, abdominal coldness and fullness, impending internal parasites. Externally, the bulb can be made into a poultice to drain pus from sores, boils, and abscesses.
Artemisia vulgaris L.	Stuart (2015)	Leaves and flowers	Used as expectorant, induce menstruation, for asthma, dyspepsia, and intestinal deworming.
Basella alba L.	Roshan et al. (2012)	Leaves, sap	Treatment of hypertension, malaria, and anemia. Reported to have antifungal, anticonvulsant, analgesic, anti-inflammatory properties.
Curcuma longa L.	Krup et al. (2013)	Whole plant	Remedy for cough, diabetes and hepatic disorders.
Cymbopogon citratus (DC.) Staph	http://tanimnicharlse.blogspot.com/p/uses-of-herbal.html	Whole plant	Used to aid digestion, stomach problems, toothache, sprain, vomiting, ringworm, and to reduce fevers.
Euphorbia hirta (L.) Lam.	Stuart (2017)	Whole plant	Used to treat asthma, coughs, diarrhea, dysentery, and dengue fever.
Ipomoea batatas L.	Stuart (2015)	Tops, leaves and edible roots	Tops, used for diabetes. Crushed leaves applied to boils and acne. Boiled roots used for diarrhea. Reports of improved platelet counts on denguepatients drinking decoction ofsweetpotato tops.
Mimosa pudica L.	Stuart (2017)	Whole plant	Roots used as diuretic, for dysentery and dysmenorrhea. Entire plant in decoction used as antiasthmatic.
Plectranthus amboinicus L.	Roshan et al. (2010)	Leaves	Useful in cephalalgia, otalgia, anorexia, dyspepsia, flatulence, colic, diarrhea, and cholera especially in children, halitosis, convulsions, epilepsy, cough, chronic asthma, hiccough, bochitis, renal and vesical calculi, strangury, hepatopathy, malarial fever, antispasmodic, and cathartic.
Portulaca oleracea L.	Eaqub et al. (2014)	Whole plant	Used for treatment of burnsand diseases related to the intestine, liver, stomach, cough, shortness of breath, and arthritis. Its use as a purgative, cardiac tonic, emollient, muscle relaxant, and anti-inflammatory.

Pb Concentrations in the Collected Medicinal Plants

Results of Pb analysis in the leaves, stems, and roots of the ten collected medicinal plants are summarized in Figure 2. In general, higher levels of lead were found in the leaves compared to the stems and roots of all the medicinal plants studied except for *A. fistulosum*.

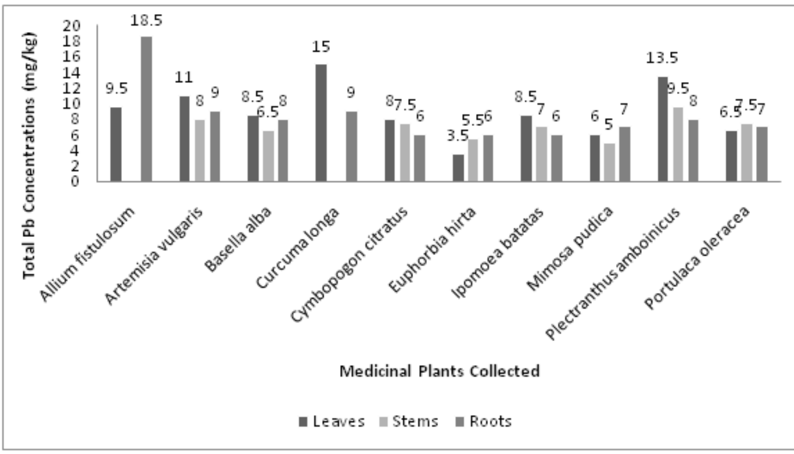

Figure 2. Lead concentrations (mg/kg) in the leaves, stems and roots of the ten collected medicinal plants

Lead concentrations in the leaf samples ranged from 3.5 mg/kg in *E. hirta* to 15.0 mg/kg in *C. longa*. Pb concentrations in *A. vulgaris* (11.0 mg/kg) and *P. amboinicus* (13.5 mg/kg) also exceeded the permissible limit of 10 mg/kg set by the World Health Organization if consumed. Jankowski et al. (2015) mentioned that the plant's diverse ability to accumulate heavy metals in the above ground parts (leaves and stems) is due to the different morphological features of these parts like surfaces covered with plant hairs, wrinkles, a spongy or stubbly structure, leaf size and leaf orientation. Fine hairs and the lobes in the leaf margins of *A. vulgaris* and *P. amboinicus* possibly help in trapping lead particles in the leaf surface while the large surface area of *C. longa* leaves may have provided a greater collection opportunity for lead atmospheric fall out.

A. vulgaris and *P. amboinicus* accumulated the highest levels of Pb concentration in the stems (8 mg/kg and 9.5 mg/kg, respectively). According to Rossi (2008), a blood lead level of 10.0mg/kg is the current threshold for lead toxicity as adopted by the United States (US) Centers for Disease Control and Prevention (CDC) in 1991 and the World Health Organization in 1995 but blood lead levels below this concentration have substantial public health impact on children and are apparently long-lasting and irreversible. Though Pb content in *A. vulgaris* and *P. amboinicus* stems were below 10.0 mg/kg, continuous exposure may result in chronic illnesses as lead accumulates in the body. In the roots or underground biomass, maximum amount of Pb was found in *A. fistulosum* (18.5 mg/kg). All the other plant samples have Pb concentrations below the permissible limit. *A. fistulosum* is a very common ingredient in Asian cuisine but the root is not usually used in cooking.

Of the 10 species, *C. longa, P. amboinicus* and *A. vulgaris* had lead concentrations in the leaves that were greater than 10mg/kg. All parts of these plants are used for medicinal purposes and are used in a variety of ailments. All parts had Pb concentrations above or near the permissible limit. These plants are widely cultivated and often established around houses and gardens.

For *A. vulgaris,* leaves, flowers and roots are the parts particularly used for medicinal purposes (Grieve, 1971). A decoction of fresh or dry leaves is usually given to treat asthma, abdominal pains, intestinal deworming and to induce menstruation (Stuart, 2015). Studies conducted by Ostrowska and Porebska (1999), Alirzayeva et al. (2006) and Dalvanda et al. (2014) showed that species of *Artemisia* can be used for the phytoremediation of polluted soils and air.

Leaves of *C. longa* is commonly used in the Philippines to add aroma and flavor to chicken or pork soup. The rhizome is used as a yellow powder which is used as a flavoring in many cuisines and as a medicine to treat many diseases like flatulence, jaundice, menstrual difficulties, hematuria, hemorrhage, and applied as an ointment to treat many skin diseases (Unissa et al., 2014).

P. amboinicus, an aromatic herb, is tolerant to a wide range of lead concentrations and nutrient deficiency (Arunbabu et al., 2014).

Soil Properties

According to Dumat et al. (2011), the behavior of lead in soil and its uptake by plants is controlled by its speciation and soil pH, soil particle size, cation-exchange capacity, root surface area, root exudation, and degree of mycorrhizal transpiration.

Soil samples were collected from the sites where the top three highest Pb accumulators were growing. As shown in Table 3, all three sites have pH close to 7.0, with Brgy. Gabas having the lowest pH of 5.41. Under acidic condition, heavy metals are more mobile and become more available below ground and vertically upward for plant uptake (Nazareno et al., 2011).

Table 3. Soil properties of the soil samples collected from where the top three Pb accumulator medicinal plants were growing

MEDICINAL PLANT GROWING	LOCATION	pH	OM (%)	Pb (mg/kg)
Artemesia vulgaris	Brgy. Sta. Cruz, Baybay City, Leyte	6.86	0.82	3.75
Curcuma longa	Brgy. Candadam, Baybay City, Leyte	6.57	3.69	7.10
Plectranthus amboinicus	Brgy. Gabas, Baybay City, Leyte	5.41	12.48	18.85

P. amboinicus in Brgy. Gabas was growing outside a rice mill and forming a very dense cluster. Figure 3a shows the cluster of *P. amboinicus* growing along the road in Brgy. Gabas, Baybay City, Leyte. The density of the plant with plenty of leaf litter in the ground and evidence of rice hull added to the soil could explain the high OM content of 12.48%, which was the highest among the three locations. The high Pb level of 18.85mg/kg in the soil where *P. amboinicus* was growing could be due to its constant exposure to vehicular exhaust coming from the many big trucks going in and out of the compound.

A. vulgaris collected along the road in Brgy. Sta. Cruz, Baybay City, Leyte was growing on sandy soil. The plants were not forming dense clusters and had little leaf litter (Fig. 3b). These could explain the small OM (0.816%) in the soil. Pb level was the least among the three sites.

C. longa was growing outside a welding shop in Brgy. Candadam, Baybay City, Leyte. The extracted soil Pb was 7.10mg/kg. Although the soil has been exposed to possible lead pollution from the nearby welding shop, the shop had just opened for less than a year. Duration of exposure is one of the factors in bioaccumulation. Most exposures to chemicals in the environment vary continually in concentration and duration (Bioaccumulation, 1993). Figure 3c shows *C. longa* planted in pots along the road.

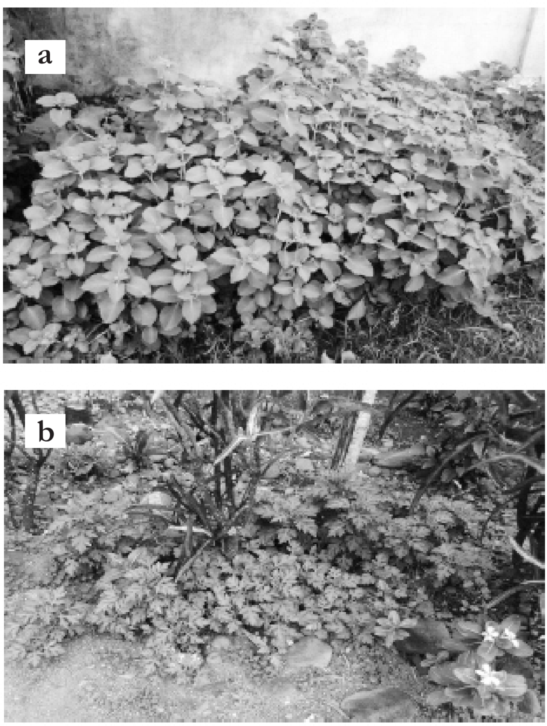

Figure 3. *Plectranthus amboinicus* (a), *Curcuma longa* (b), and *Artemisia vulgaris* (c) growing along the Baybay-Ormoc Highway

CONCLUSION AND RECOMMENDATIONS

Curcuma longa, Plectranthus amboinicus, and *Artemisia vulgaris* can accumulate high Pb concentrations in the leaves. The Pb levels in the leaves exceeded the permissible limit of 10mg/kg set by the World Health Organization (WHO). In the stem, *Mimosa pudica* had the lowest with 5.0 mg/kg while *Plectranthus amboinicus* had the highest with 9.5 mg/kg. In the roots, Pb was highest (18.0 mg/kg) in *Allium fistulosum*. All the other plants had Pb levels below 10.0 mg/kg in the roots. This could mean that the aforementioned plants are potential Pb bioaccumulators. Therefore, caution should be taken when collecting or growing these medicinal plants. To ensure their safe use, these plants should not be collected nor planted along busy streets due to their ability to accumulate high levels of Pb mostly from vehicular exhaust. Long term usage and consumption of large quantities of Pb-contaminated plants may lead to increased blood Pb levels resulting to serious health problems.`

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