Comparison of Lead Absorption Ability of Bougainvillea (*Bougainvillea Spectabilis* L.) Leaves in Two Cities in Metro Manila, Philippines

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***Abstract*—Heavy metals, such as lead, have caused deleterious effect not only to the environment, but also to the public's health. In the Philippines, the ornamental plant Bougainvillea has been planted on the main roads of cities due to its capacity to thrive in heavily polluted areas. Studies show that Bougainvillea may be utilized to reduce heavy metal pollution through absorption and adsorption in soil and air, respectively. In this study, the plant's leaves were used to measure the lead accumulated, adsorbed and absorbed from two cities in Metro Manila, specifically Las Piñas and Manila. The lead concentration of the plant and its soil was measured through Flameless Atomic Absorption Spectrophotometer (AA-6300, Shimadzu, France), and the duration of measurement lasted for nine months with four time periods (0, 3, 6 and 9th month-interval). Two-way t-test and ANOVA were used to analyze the data gathered. It was found that there is no sufficient evidence to conclude that lead content of the plants in Manila differs significantly from that of Las Piñas. Moreover, results show that Bougainvillea lead uptake may vary depending on various environmental factors, such as concentration of lead in soil, climatic condition, degree of heavy metal pollution and complexes of lead form in other soil components.**

***Index Terms*—Bougainvillea, flameless atomic absorption spectroscopy, heavy metals, lead absorption ability.**

I. Introduction

Heavy metals are present as pollutants in the air which may cause harm to the public. According to the World Health Organization (WHO) heavy metals such as lead in air of Manila are greatly exceeding the established safety limits, and concentrations of suspended particulate matter are dangerously high. With this fact, air pollution in the country has been a problem which requires attention, monitoring and long term solutions. Majority of the sources of air pollution come from automobiles, gases from burning of coal and fossil fuels, as well as smelting of iron and non-ferrous metals [1].

Lead in particular has been the heavy metal of interest in most of the studies because of its deleterious effect not only in the environment but also to public's health as it accumulates through time [1]. Moreover, lead is one of the most common contaminants in urban soil that can be taken up by the plants. Majority of lead in the environment come from air borne emission and deterioration of lead based paint. Lead from the soil can be uptake by the plant through its root or leaves. According to the study conducted by Yan-Ju and Hui in 2008 [2], plants provide enormous leaf area for impringement, absorption and accumulation of air pollutants to reduce their levels in the environment including air borne lead. The ability of plant to absorbed lead from two sources soil and air has a great environmental significance in phytoremediation of heavy metals [1].

In the Philippines, bougainvillea has been recommended by the Metropolitan Manila Development Authority to be used as ornamental plant in the main roads of the city due to its capacity to thrive in heavily polluted area such as urbanized city. Although it has not been used as bioindicator, it has been determined that this plant accumulates heavy metals such as Nickel [3] and may be utilized as one of the plants used to reduced heavy metal pollution from the environment.

In this study, bougainvillea leaves were used to measure the lead accumulated, adsorbed and absorbed from two cities in Metro Manila, specifically Las Piñas and Ermita Manila. Las Piñas is known as one of the cleanest cities in Metro Manila belonging in the list of "Clean and Green Hall of Fame" awarded by the Philippine government. It is also the first local government unit in the Philippines that has received the prestigious Global 500 roll of Honour of the United Nations Environment Programme. Manila on the other hand is the capital of the Philippines. The district of Ermita in Taft Manila was reported to be the most air polluted district in Manila [4]. The main objective of this study was to determine and compare the ability of *Bougainvillea* spectabilis L. (Fam. Nyctaginaceae) leaves to absorb, adsorb and accumulate lead situated in the two cities. The specific objectives of this study are to determine the ability of bougainvillea to absorbed and adsorbed airborne and soil borne lead determined at 0, 3, 6, 9-month period by Flameless Atomic Absorption Spectroscopy and to determine if there is a significant difference in the accumulation and absorption of lead among the bougainvillea plants in the two cities.

II. Methodology

A. Procurement and Planting of Bougainvillea

1) Materials

Plant Samples –Ten (10) Bougainvillea plants were purchased from Manila Seedling Foundation, Inc. The initial lead concentration of the plant and its soil were determined

Manuscript received December 5, 2012; revised February 15, 2013. This work was supported in part by the Saliksikan para sa Kalilkasan and the University of the Philippines College of Pharmacy.

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DOI: 10.7763/IJBBB.2013.V3.194

using Flameless Atomic Absorption Spectroscopy (FAAS). Plant samples were randomly assigned to two groups. The first group, labeled as the polluted group, was planted along the vacant area in the College of Pharmacy along Pedro Gil Street. The second group, labeled as the unpolluted group, was planted in a park in Las Piñas.

Soil Samples –soil samples from the two groups were collected. The soil lead concentrations were determined using Flameless Atomic Absorption Spectroscopy (FAAS).

Chemicals/Reagents –Nitric acid, Distilled Water

Instruments – Flameless Atomic Absorption Spectrophotometer (AA-6300, Shimadzu, France), FAAS controlled by a personal computer using WizAArd software

B. Plant Harvesting and Heavy Metal Analysis

Harvest of the plant samples were done at three time periods (3months, 6months, 9 months). For each harvest period, 1g of mature leaves from each of the five bougainvillea plants planted in the selected sites (Manila and Las Pinas) was collected. Per group, the leaves were oven dried at 80^oC for 24 hours. The samples were crushed into fine powder and sieve through 1.5 mm sieve [1]. To 1.0 g of the samples per each group, 10 mL of mixed solution of nitric and hydrochloric acid (4 HNO_3:1HCl) was used to macerate the sample for seven days in closed polyethylene containers [1]. The samples were digested for 2 hours in 200^oC, until wet salts were obtained. Samples were then diluted to 50mL with distilled water and analyzed by FAAS [1]. For the soil samples, 2.0 g soil were weighed per group then 4 mL of aqua regia(HCl/ HNO_3, 3:1) was added. The samples were digested in a hot plate for three hours. The digest were filtered and made up to 20 mL with deionized water, transferred in polyethylene containers and stored at 4^oC until analysis [1]. The leaves were macerated overnight for pre-digestion. The samples were then heated using a water bath maintained at 80-100 ℃ for 5 hours, cooled, filtered and filled with distilled water to volume in a 50 mL volumetric flask [1]. The samples were transferred and stored in PET bottles prior to FAAS[1].

1) Flameless atomic absorption spectroscopy

The lead content of the samples was analyzed using flameless atomic absorption spectrophotometer (AA-6300, Shimadzu, France) controlled by a personal computer using WizAArd software. Measurements were carried out at 217.0 nm with 0.7 nm low slit and 5 mA electric current [5]. Prior to analysis, the spectrophotometer was calibrated with standard lead solutions (0.05, 0.1, 0.50, 1.00, and 5.00 ppm for the plant samples) using distilled water as blank. The standard solutions and distilled water were provided by the Chemistry Instrumentation Laboratory of the De La Salle University, Taft Avenue, Manila. Lead concentration levels were expressed in ppm unit.

C. Analysis of Data

Data were evaluated using the Data Analysis program of Microsoft Excel©. Student's two-way t-test: two samples assuming unequal variance was used to compare the lead concentration in the leaves of the two groups. Anova single factor was used to determine if there is a significant difference in the amount of lead accumulated in different time periods.

III. Results and Discussion

Table I shows that the total lead concentration (ppm) in soil samples is higher in Las Piñas than in Manila.

TABLE I: Lead Concentration (PPM) in Soil Samples in Manila and Las Piñas

	Manila	Las Piñas
Lead in soil	0.042467	0.51333

A. Heavy Metals in Plants in Manila

Result of lead concentration present in bougainvillea plant in Manila is shown on Table II.

TABLE II: Amount of Lead in Plant in the Polluted Group at Different Time Periods

Polluted environment	Baseline lead content (ppm)	3rd month Lead content (ppm)	6th month Lead content (ppm)	9th month Lead content (ppm)
P1	0.0049	0.2873	Not detectable	Not detectable
P2	0.0501	Not detectable	0.0011	0.035
P3	0.0689	0.0463	0.0162	Not detectable
P4	0.099	Not detectable	Not detectable	0.0237
P5	0.0802	0.0539	0.0011	0.02
Mean	0.3031	0.3875	0.0061	0.0787

It shows that bougainvillea plants planted in Manila varies in the amount of lead absorbed at a particular time period despite their similarity in terms of location, age and species. Fig. 1 shows that the mean concentration of lead in the bougainvillea plants was highest during the third month, October 2011, and lowest during the sixth month, January 2012. Such can be explained by the weather condition within which the samples were collected. The prevalence of rain was higher during the sixth month. The lead that might have been impringe in the leaves of the plants might have been wash away resulting to lower lead concentration detected during the sixth month. Aside from the mechanical removal of the lead in the leaves the lead deposited in soil can be washed off through mechanical removal such as soil erosion. Lead can also form complex to the components of the soil inhibiting the plants ability to absorbed lead from the soil.

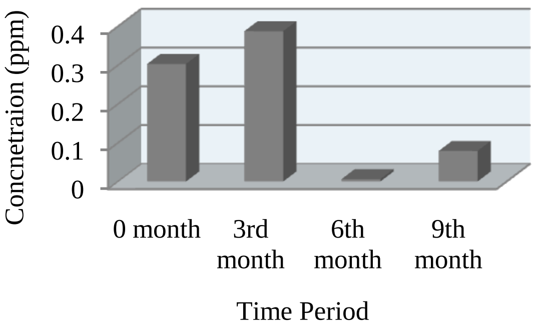

Fig. 1. Mean lead concentration (ppm) uptake of Bougainvillea in Manila.

B. Heavy Metals in Plants in Las Piñas

Result of lead content present in bougainvillea plant in Las Piñas is shown on Table III.

TABLE III: AMOUNT OF LEAD IN PLANTS IN THE UNPOLLUTED GROUP AT DIFFERENT TIME INTERVALS

Unpolluted environment	Baseline lead content (ppm)	3rd month lead content (ppm)	6th month lead content (ppm)	9th month lead content (ppm)
P1	0.0501	0.035	0.0501	0.0124
P2	0.0463	0.0313	0.0501	0.0689
P3	0.0764	0.0727	Not detectable	0.0162
P4	0.084	0.0162	0.0802	0.0915
P5	0.0915	0.084	0.0539	0.0313
mean	0.0696	0.04784	0.05858	0.04406

It shows that individual bougainvillea plants planted in Las Piñas varies in the amount of lead absorbed at a particular time period despite their similarity in terms of location, age and species. Fig. 2 shows that the mean concentration of lead in the bougainvillea plants was highest during the sixth month and lowest during the ninth month. The results can be explained by the variations in the weather condition within which the samples were collected. The prevalence of rain in Las Piñas was higher during the ninth month.

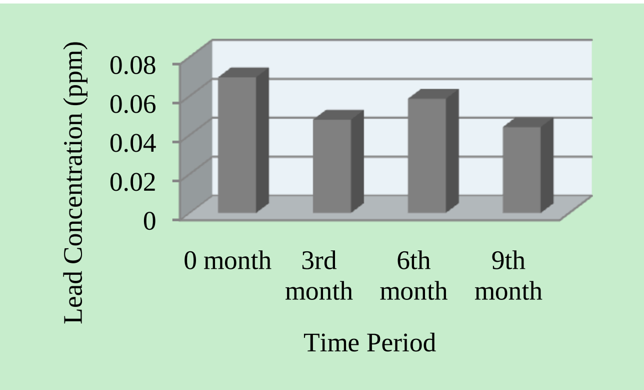

Fig. 2. Mean Lead Concentration (ppm) uptake of Bougainvillea in Las Piñas.

Overall, comparing the amount of lead detected in the two cities, the bougainvillea plants in Las Piñas area contain greater amount of lead than the bougainvillea plants in Manila.

The result of t-Test presented in Table IV shows that there is no sufficient evidence to conclude that the lead content of the plants in Manila differs significantly from the lead content of the plants in Las Piñas.

TABLE IV: T-TEST RESULT OF LEAD CONTENT IN MANILA AND LAS PINAS

	Manila	Las Piñas
Mean	0.056264286	0.054847368
Variance	0.005325895	0.000691306
SD	0.072978728	0.026292698
Observations	14	19
Hypothesized Mean Difference	0	
Df	16	
t-Stat	0.069402919	
P (T<=t) two tail	0.94552891	Not significant
T Critical two-tail	2.119905299	

The result of ANOVA presented in Table V shows that there is no sufficient evidence to conclude that lead content of the bougainvillea leaves increases or decreases significantly over time. Moreover the result is further supported by the variations and absence of patterns in the mean lead levels detected in the soil and the plants at different time periods.

TABLE V: ANOVA SINGLE FACTOR OF LEAD CONCENTRATION IN DIFFERENT TIME PERIODS

Source of variation	SS	df	MS	F	P-value	F crit
Between groups	0.01036	3	0.00346	1.4045	0.26143	2.9340
Within groups	0.07133	29	0.00246			
Total	0.08169	32				

The result of accumulation and absorption of the bougainvillea plant in the study can be accounted to external factors that might have affected the plants' capacity to uptake lead from the environment. The presence of lead in plants is essentially due to the absorption of atmospheric lead directly from their leaves or from their bark [6]. However plants have different methods to entrapped or removed heavy metal contaminants in the soil. There were already variations in their initial lead content prior to the start of the experiment that may cause the differences in the lead concentration of plants in different time period. Another factor which might affect the lead uptake is the concentrations of heavy metals in soil [6]. Lead in soil can be transported to other places during heavy rainfall, and soil erosion. During the 3rd (October 2011) and 6th month (January 2012), heavy rainfall was experienced in the Taft area as compared to Las Piñas thus the air borne lead adsorbed by the plant through their leaves might have been washed off during the collection period. Moreover Taft area was often flooded as compared to Las Piñas and thus the lead that possibly present in soil may be washed off resulting to lower lead level retain in the soil.

IV. CONCLUSIONS AND RECOMMENDATIONS

Lead uptake of bougainvillea plant species planted in Manila and Las Piñas was studied. Results show that bougainvillea lead uptake may vary depending of different environmental factors such as concentration of lead in soil and climatic condition, degree of heavy metal pollution, and complex of lead form in other soil component. The study recommend the used of simulated soil and controlled environment to minimized the effect of extraneous variables that might affect the absorption and adsorption of lead in bougainvillea plant to established the plants ability to absorbed lead before testing it to the actual environment.

ACKNOWLEDGMENT

The authors thank the University of the Philippines Manila, College of Pharmacy for their generous support in making this paper possible. They would also like to thank the following contributors who have shared their time and expertise in the attainment of the objectives of this study, namely: (1) Aninon, A.D., (2) de Luna, A., (3) Bacala, C., (4) Cosme, K., (5) Rodriguez, C., (6) Ong, A., (7) Real, M., (8) Paguirigan, J., and (9) Alvarado, J.

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