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Lead Content of Plant Leaves in Cebu City, Philippines

Concepcion S. MENDOZA[1] and Joyce HIPE[2]

1: Chemistry Department, University of San Carlos, Talamban, Cebu City, 6000, Philippines
E-mail: concepcionsmendoza@yahoo.com

2: Deceased, Dec. 25, 2005

Abstract

This study was conducted to determine the lead concentration in plant leaf of ipil-ipil (*Leucaena leucocephala*), gatas-gatas (*Euphorbia hirta*), bila-bila (*Leucine indica*) and basikad (*Cyperus icyllingia*) collected from N. Bacalso Street, University of San Carlos (USC) Retreat House and from Buhisan Dam, using the atomic absorption spectroscopy (AAS) method.

Appreciable amounts of lead concentration were found in plant species collected from USC Retreat House and in N. Bacalso Street, during the dry (averaged Pb ranging from 29-88 ppm) and wet (averaged Pb ranging from 3-38 ppm) seasons. Averaged lead concentration at dry season was found higher in N. Bacalso Street (55-88 ppm Pb); a commercial site which is exposed to greater pollution from transportation exhaust, than in USC Talamban Retreat House (29-43 ppm Pb), located uphill at ~1km away from less busy road but situated also a few kilometers from industrial area. Buhisan Dam is a remote rural background site, had lead concentration below the detection limit of 0.078 ppm, for both seasons. Lead levels were higher in plants during the dry season than the similar plants of the wet season. The plant leaf, ipil-ipil from N. Bacalso Street during the dry season had the highest averaged lead concentration of 88 ppm. Moreover, traffic density, distance from traffic roads, industrial activity, climate, topography (uphill or downhill) and nature of plant leaf species were influencing factors in lead levels in plant leaf samples.
Keywords: Cebu City (Philippines), lead, plant leaves

Introduction

Pollution is one of the most serious problem in our society today. In highly urbanized areas the exhaust from vehicles and industries are the major contributor to air pollution (CUNNINGHAM 1990). Cebu City is the second urbanized city in the Philippines. Along with this progress is the increased air pollution (WORLD BANK TEAM 2000, DENR-EMPAS 1998).

Studies have detected significant amount of lead in air particulates (ADARNA 2003, MENDOZA 2001), in soil (ADARNA 2003, MENDOZA *et al*. 2000), in water (SUICO

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2003, MENDOZA *et al*. 1995), and in human milk (SUICO 2003) of Metro Cebu. Plants also plays a major role in the absorption of some pollutants in the environment. Plants grown within this area can accumulate lead from the atmosphere, water or from soil, and translocation into the plant tissue. Lead accumulation in plants can lead to human exposure to this carcinogenic metal (LUGON-MOULIN *et al*. 2006). To better define actual lead distribution in plants, leaves of selected plant species of ipil-ipil (*Leucaena leucocephala*), gatas-gatas (*Euphorbia hirta*), bila-bila (*Leucine indica*), and basikad (*Cyperus acyllingia*) found along selected roadside vegetation within Cebu City were analyzed, as biological indicator of lead pollution in the environment. This is a preliminary survey which may help identify regions with low- or high- lead concentrations and to obtain insight in the cause of concentration extremes.

Methodology

Location/ Sampling Site

Samples were collected from the three different sampling areas in Cebu City, as shown in Fig. 1. The areas were Talamban Water Catchment (within the vicinity of the USC Retreat House) (1), N. Bacalso Street (2), and Buhisan Dam (3) .

The N. Bacalso Street is within the downtown of Cebu City. Along the area are establishments, such as schools, hospital, shopping mall, residential and squatters area, gasoline stations, and a terminal for public utility transportation. Vehicles of different types pass by the site everyday. It is also within nearby roads of high traffic density. Exhaust from the engine of these vehicles is very evident.

The USC Retreat House and Buhisan Dam have a relatively different description. USC Retreat House is about 1 km from the less busy road and bounded a few kilometers with industrial activities of Mandaue City. On the other hand, Buhisan Dam is a Department of Environment and Natural Resources (DENR) protected area; a very remote rural area and is considered as the nearby control area. It is relatively far from pollution. Both sites are surrounded by trees and are situated in the mountain.

Sample Collection

An ocular inspection was conducted first to determine which weeds are growing in common to all the sampling sites. Plant leaves of different plant species, preferably those low-lying plants such as the weeds were considered. The plants chosen were ipil-ipil (*Leucaene leucocephala*), gatas-gatas (*Ephorbia hirta*), bila-bila (*Lecine indica*), and basikad (*Cyperus icylingia*). Plant samples were collected during the dry season of June to July 2003 and on the wet season of November to December 2003. Samples gathered were placed in separate plastic containers so as to avoid contaminations from the other samples.

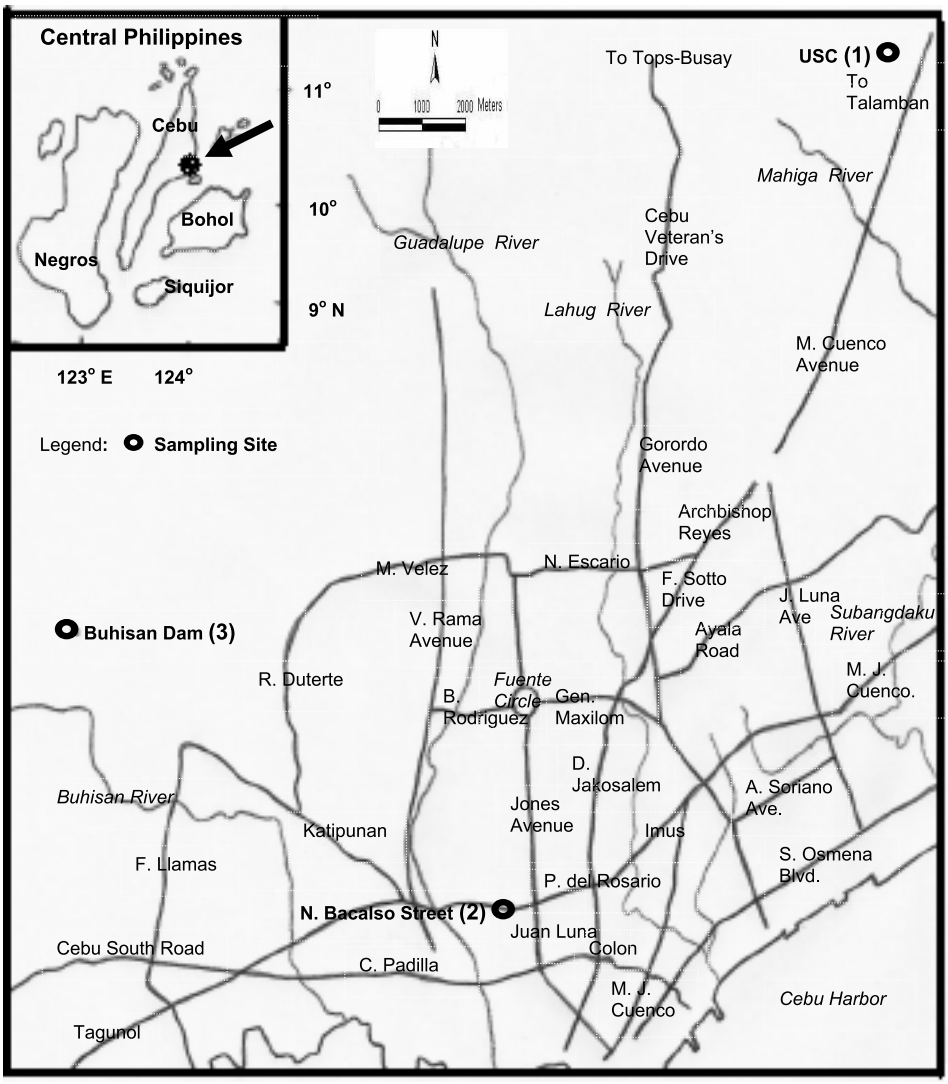

Fig 1. Road map of Cebu City, showing together the location of sampling sites: (1) USC Retreat House, (2) N. Bacalso St., and (3) Buhisan dam.

Plant Samples

Weeds were chosen to be the plant sample. These species not only grows in most areas but also to the fact that these plants can withstand adverse weather conditions, such as heat, flood, and most of all pollution (SEIDENSCHWARZ 1994). These weeds can grow easily on roadsides which may be easily and directly affected by pollution; like lead pollution from the exhausts of vehicles.

According to SEIDENSCHWARZ (1994), the considered plants in this study has the following characteristics. Bila-bila (*Leucine indica*) a tufled glabrous grass 30-70 cm tall. The species grows in human settlements at all elevations. It is very resistant to

trampling and grows along road footpaths.

Basikad (*Cyperus icyllingia*), a low annual grass-like herb with triangular stem and globose inflorescence. The small white flower heads look like buttons. The plant grows on wet open grasslands.

Gatas-gatas (*Euphorbia hirta*) is a small hairy weed, up to 60 cm which is usually not branched. It grows on sunny, dry places on riverbanks and waste places around settlements.

Ipil-ipil (*Leucaena leucocephala*) is a panthothenic leguminous shrub or small tree. The compound leaves are 10-20 cm long, with 10-18 pairs of small leaflets along each primary branch. The numerous small white flowers are in globular flower clusters. This plant is found in settled areas at low and medium altitudes. It grows in various types of soil. Its resistance to high temperature, shade, drought, and salinity may account for its widespread distribution. Ipil-ipil is not actually a weed but rather a shrub or a small tree. It was chosen to be the one of the plant samples since it was found common to both sampling sites. The plant can also provide a wider variety of plant as samples.

Lead Determination Using the Atomic Absorption Spectrophometry

Sample preparation and analyses were done according to accepted method (PERKIN-ELMER 1982). The unwashed whole leaf samples collected were air dried until the leaves became brown in color, and then dried in an oven at 100℃ to ensure that no moisture was left in the samples. The samples were then pulverized in an electric grinder, to increase the surface area for more efficient digestion. The prepared samples were placed in a dessicator to avoid moisture. From the bulk sample, 0.500 gram of each sample was taken for digestion. A 5 mL concentrated HNO_3 was added to the plant sample and the mixture was allowed to stand overnight. The mixture was heated carefully on a hot plate until production of red NO_2 fumes had ceased. The mixture was cooled and 2 mL of 70% $HClO_4$ was added into the mixture. The mixture was again heated and allowed to evaporate to a small volume. The mixture was filtered and the filtrate was transferred into a volumetric flask and diluted to volume with distilled water. The resulting solution was then analyzed for total lead (containing the adsorbed and absorbed lead on leaves) by atomic absorption spectroscopy (AAS), following the instrument's settings and condition.

As reference, a sample blank using distilled water, was prepared by carrying the specified quantities of acids through the entire analytical procedure. In the calculation of the lead content in plant leaves, the sample absorbance was corrected by subtracting the absorbance of the sample blank.

Results and Discussion

Plant uptake of metals may not only be derived through the root system, but may

arise from various sources of superficial contamination. Above-ground parts are not only liable to become contaminated with soil during sampling, but are also exposed to atmospheric deposits throughout the whole period of growth. Deposition of metals from point source emitters can locally completely obscure the true uptake from the soil and can have very widespread effects. Much of the deposited particulate matter can be washed from the leaf surface and does not appear to enter the plant tissues. Any water soluble forms deposited on leaves, however, may enter the plant. Elements associated with very small particles (below 2μm diameter) would be more susceptible than clay or soil particles to dissolution in acid rain water and could contribute to the true leaf contents. Some elements are readily taken up by plant leaves from the gaseous stream. It is for these reasons that the passive accumulation monitoring by determining total metal or total lead content in similar unwashed plant leaves about an extended period of time on the sites (supposedly of similar soil types) is being considered in this study.

Random plant leaf samplings and analyses has been performed during the dry season (June-July 2003) and wet season (November-December 2003) to study the effect of seasonal variation, if any. The lead concentration found in each plant specie is presented in Table 1. These results were attributed by some prevailing factors. Traffic density, distance from traffic roads, industrial activity, climate, area topography (up and downhill) and nature of plant leaf species were influencing factors that lead to lead levels in plant leaf samples.

Table 1. Lead concentration (ppm) in plant leaves collected from Cebu City during 2003.

PLANT LEAF	SITE	DRY SEASON		WET SEASON	
		Ave Pb (± SD)	Range	Ave Pb (± SD)	Range
Ipil-ipil	1	34.3 (± 32.9)	11.1-57.6	9.9 (± 16.9)	<DL-29.4
	2	88.0 (± 8.6)	81.9-94	37.9 (± 37.9)	<DL-65.8
	3	<DL	<DL	<DL	<DL
Gatas-gatas	1	37.6 (± 34.5)	13.2-62	5.3 (± 7.4)	<DL-10.6
	2	71.0 (± 5.2)	66.8-74.2	59.2	-
	3	<DL	<DL	<DL	<DL
Bila-bila	1	28.8 (± 5.5)	9.2-31.2	2.7 (± 4.5)	<DL-7.8
	2	61.3 (± 20.2)	47.0-75.6	24.9 (± 43.0)	<DL-74.6
	3	<DL	<DL	<DL	<DL
Basikad	1	42.5 (± 36.3)	16.8-68.2	4.9 (± 8.3)	<DL-14.4
	2	55.0 (± 9.1)	48.6-61.4	27.2 (± 32.5)	<DL-64
	3	<DL	<DL	<DL	<DL

Site : 1- USC Retreat House, 2-N. Bacalso Street, and 3-Buhisan Dam.
Detection Limit, DL = 0.078 ppm ;
Number of plant sampling/site/season, N = 3, except for Gatas-gatas at N. Bacalso St., wet season where N=1 ;
Degree of variation is expressed in standard deviation, SD, value.

Generally, all plants collected from USC Retreat House (ave. Pb: dry = 29-43, wet = 3-10 ppm) and Buhisan Dam (<0.078 ppm Pb for both seasons) were of lower lead concentrations as compared with samples collected from N. Bacalso Street (ave. Pb: dry = 55-88, wet = 25-59 ppm). The difference in the concentrations between the sampling sites is justified by the amount of pollution in the said sampling sites. N. Bacalso Street is also known as the South Express Way where all sorts of vehicles passes by everyday. Exhaust from these vehicles is the major contributor of pollution, with much of the lead released to the air and is deposited onto the land or surface water (HARRISON *et al*. 1983, SAMARA *et al*. 1990, ATSDR 2005). Thus, plant species within N. Bacalso Street are more easily affected by transportation pollution, as compared to the plants in USC Retreat House and Buhisan Dam. Pollution studies made by Cunningham (1990) also supports this finding. This preliminary investigation is a general indication of the distribution pattern of lead in plants exposed to motor vehicle exhaust along busy thoroughfare of Metro Cebu.

The USC Retreat House and Buhisan Dam are sites away from vehicle exhaust pollution. So, even if samples were gathered away from the busy street, like in USC Retreat House, still lead concentrations (averaged Pb: dry = 29-43, wet = 3-10 ppm) were detected in samples. Transportation pollution and in part, industrial pollution, from Cebu City and Mandaue City maybe carried by the wind to the uphill areas of USC Retreat House. A neighboring locality of USC Retreat House is Mandaue City, with industrial activities. The wind was generally blowing from south to north direction during the months of June to July, and a wind direction blowing from south to southwest during the month of November (PAG-ASA 2003c). Another possibility of lead source at USC Retreat house is due to the ongoing construction. Bulldozers and trucks carrying soil and gravel; and taxis and other private vehicles also passes by more often. Exhaust from these vehicles maybe blown off by the wind from the road to where samples were gathered. At Buhisan Dam, the lead concentration of collected plant leaves were below detection limit of 0.078 ppm Pb for samples collected.

These lead results found in leaf samples from N. Bacalso Street, USC Retreat House and in Buhisan Dam relates well with previous studies. Similar trend (MENDOZA 2001) was observed for lead content in total suspended air particulates from a nearby area of N. Bacalso Street (in Pardo = 0.1 μg/m^3 Pb) > nearby area of USC Retreat House (at DENR-7 = below detection limit) ~ Buhisan Dam (in Camp Forestal). Another study (ADARNA 2003) showed that samples from Kamagayan (near N. Bacalso Street): in air particulate = 0.10 μg/m^3 Pb and in top soil = 0.10 mg/kg Pb, while environmental samples from Talamban: in air particulate = 0.08 μg/m^3 Pb and in topsoil = 0.06 mg/kg Pb. The lead content in top soil is still below the 400 mg/kg lead, as guidance value for residential soils (US-EPA 1986). The human body is also contaminated with lead. Breast milk of the mothers collected from Kamagayan had higher concentrations compared to that collected from Talamban area (SUICO 2003); though Pb values are still within the FDA's action level of 0.5 μg/mL for lead in products for use by infants and children use (FDA 1994). Such results were mainly attrib-

uted to vehicular and industrial emissions and wind direction towards the environment of the sampling sites (MENDOZA 2001, ADARNA 2003, SUICO 2003)

The distribution pattern of lead in plants exposed to motor vehicle exhaust is more prominent in summer or dry months. The dry season gave higher averaged lead concentration than the wet season, for all plant leaves species. During the dry season, pollution is easily carried by the wind. There is wider distribution of pollution into the atmosphere and hence easily deposited and absorbed by the plants. During the rainy season, lead particulates are easily washed off by the rain and settled down to the ground.

Based from PAG-ASA (2003a-c), the average rainfall amount was 82.1 mm, 381 mm, 94.2 mm during the month of June, July and November 2003, respectively. July is supposedly a dry month but due to weather abnormalities, July showed to be an intermediate of a dry and wet month. This is evident by a high amount of rainfall on July. And though, the rain in July were mostly drizzles, but the amount of rainfall is 4 times larger than the rainfall in November. In such wet situation, the dispersion of dust-containing lead to other area may be difficult. The lower averaged value of lead observed in the wet season (November-December) may be caused by the washing out of dust-containing adsorbed lead from the leaves.

Generally, the lead concentrations for all plant leaf species from N. Bacalso Street (dry and wet seasons) and USC Retreat House (dry season) were approximately more than 10 ppm. The lead values were also higher than the value set in lettuce for human consumption, having the tolerable limit of lead at 7.5 mg/kg of leaf material (FELLENBERG 2000). Thus, edible plants grown in these areas may be also contaminated with significant amount of lead.

During the dry season at N. Bacalso Street, the lead concentration in plant species sampled decrease in the order: Ipil-ipil (88 ppm) > Gatas-gatas (71 ppm) > Bila-bila (61 ppm) > Basikad (55 ppm). The nature and condition of plant surfaces, which vary with species have a marked effect on the retention of atmospheric deposits (BERROW *et al*. 1991). Ipil-ipil have compound leaves which allow greater surface area to accommodate deposited particulates. Ipil-ipil also grows tall than the low growing plants (like Gatas-gatas, Bila-bila, and Basikad). Thus, Ipil-ipil can catch more pollution than the mentioned plant species. For example the pollution from the higher leaves is washed off by rainwater, the leaves at the lower part of the plant can still catch the washed off particulates. While, the Gatas-gatas leaf with rough and hairy leaf margin can retain far more particulates than the smooth hairy leaf of Bila-bila, and the smooth, hairless leaf of Basikad. Such comment has to be clarified, considering the uncertainty (big SD value) in the obtained result for bila-bila and basikad. However, the nature and condition of plant surfaces which vary with species, plant part and stage growth have a marked effect on the retention of atmospheric deposits (BERROW *et al*. 1991).

It is rather unsafe to make a comparison between the Gatas-gatas data obtained during the wet and dry seasons at N. Bacalso Street. There was a limitation of sam-

pling collection during the wet season. The value of 66.8 ppm Pb cannot be considered the averaged highest concentration since the said value was for one sampling only. Gatas-gatas is not a perennial plant and grows only on sunny dry places (SEIDENSCHWARZ 1994). The N. Bacalso Street is an easily flooded-plain causing the non-survival of Gatas-gatas during rainy season. While the draining of water over the hills of Buhisan Dam and USC Retreat House, allows the growth of Gatas-gatas.

Because of lead's importance as a cause of public health problems, a number of federal agencies have issued advisory standards or enforceable regulations that set lead levels in different media (ATSDR 2005). In the Philippines, lead level at ambient air is set at 1.5 ug/m^3 averaged over a three month period (DAO 1993). There is still no standard value for lead in plants set by monitoring agencies. Further study has yet to be done especially in the Philippines in order to conclude the effect of pollution on plants; especially edible plant, in the country. To investigate the geographical extent of the problem, intensive and widespread monitoring of soil, air, water, plants and other environmental samples for lead would be necessary to be able to perform a full mass balance study at an appropriate number of sites.

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