DETERMINATION OF MERCURY AND LEAD IN AMBIENT AIRAND THE KNOWLEDGE, ATTITUDES AND PERCEPTIONS OF THE RESIDENTS IN THE PRESENCE OF THESE METALS IN NAGA CITY, CEBU, PHILIPPINES

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Abstract: Due to the industrial and economic growth in the City of Naga, there were growing concerns in the quality of air the residents were breathing. With this, the presence of mercury (Hg) and lead (Pb) in the ambient air was determined from the total suspended particulate (TSP) samples. The samples were procured from DENR-7 collected from August to December 2012 and analyzed by atomic absorption spectroscopy (AAS). The criteria set by Philippine Clean Air Act (PCAA) of 1999 were used as reference standards of these heavy metals. Likewise, household surveys were conducted from December 2013 to January 2014 to assess the knowledge, attitudes and perceptions of the residents to the presence of Hg and Pb in their locality. There were six barangays chosen due to their proximity to the major pollution sources. The results of the study showed that the average concentration of Hg was 1.80 x 10^{-7}µg/Nm^3 , while Pb was < 6.57 x 10^{-7}µg/Nm^3 in the TSP samples. The trends of the Hg and Pb concentration were way below the standard of the PCAA and indicated that the ambient air quality of Naga was not yet polluted with Hg and Pb pollutants during the study period. However, the household survey revealed that 78% of the residents believe that their locality was already polluted by Hg and Pb due to the presence of the industrial plants in their place. The perception of the residents did not coincide with the laboratory results probably due to the time difference of the survey and the sampling period.

Keywords: Air Quality, Total Suspended Particulate, Atomic Absorption Spectroscopy, Heavy Metals, Naga City.

I. INTRODUCTION

With the industrial and economic growth in the City of Naga, there are growing concerns that the residents in the city are inhaling polluted air. As reported by Cebu Daily News dated April 16, 2010, a group of environmental advocates collected samples of coal ash (a waste product of coal combustion) in the 12 dumping sites in the city on January 18, 2010. The analysis of the samples was conducted by Philippine Institute of Pure and Applied Chemistry (PIPAC) in Ateneo de Manila University and showed that the ash contained heavy metals: arsenic, cadmium and mercury with the range of 8 – 25, 1.8 – 4.5, and 0.03 – 0.09 µg/g, respectively. However, the report did not indicate if the measured concentrations were above or below the standard. Heavy metals in high concentrations are considered toxic substances, and thus must be closely regulated by law.

The DENR-EMB 7 had its monitoring station in the city located in the residence of Cornilla Lao at the boundary of Barangays Inuboran and Langtad that monitored only the total suspended particulate matter (TSP) level.It was reported in Cebu Daily News on May 3, 2012 that the Naga monitoring station located between the two barangays in the city failed in the one-year "ambient air quality monitoring" of EMB 7 that ended on December 2011. The 2012 Ambient Air Quality Status reported that Naga Station had an annual geometric mean of 123.78 µg/Nm^3 which exceeded the 90 µg/Nm^{3}annual guideline value for TSP, set forth in Rule VII, Section 1 (a) of the Implementing Rules and Regulations (IRR) of Philippine Clean Air Act [1]. The result showed that for the last two years the annual level of TSP in the area was beyond the standard and needed special attention.

The measurement of metal concentrations in TSP, particulate matter PM10 or PM2.5 give some indication of the general levels of pollution, but provided no information on size distribution of the pollutants. From a toxicological point of view, the most important particles were those with a diameter <10 µm (PM10), so-called respirable fraction, which penetrate the human respiratory system deeply [2]. It was well established that fine particles (smaller than 2.5 µm) penetrate the pulmonary region and tend to deposit in the alveoli causing adverse health effects leading to pulmonary and respiratory diseases [3].

The elevation of TSP level in the City of Naga against the annual guideline value as reported by the latest DENR-EMB 7 ambient air quality status might correspond to an increase concentration of heavy metals like Hg and Pb present in particulate matter, thus this study is conducted. The knowledge, attitudes and perceptions of the residents about the toxicity of Hg and Pb were also conducted to confirm or disregard the speculation, verify the information, necessitate recommendation of possible actions to the authorities in the monitoring Hg and Pb in ambient air.

II. DETAILS EXPERIMENTAL

2.1. Materials and Procedures

The TSP samples collected for 24-h through high-volume sampler set up by DENR-EMB 7 was used to determine the Pb and Hg in ambient air. The samples were brought to Ostrea Mineral Laboratories, Inc. (OMLI) for chemical analysis. The determinations of Pb and Hg in the particle phase were prepared using the method of acid extraction and digestion of the glass-fiber filters prior to analysis. The digestion of the samples for Pb and Hg analysis was following the USEPA CFR 40, Part 50, Appendix A and B -Reference Method and Methods of Air Sampling and Analysis, 3rd Edition. The Pb in the samples was analyzed using FAAS at the wavelength of 283.3 nanometer (nm) and by using CVAAS for Hg at the wavelength of 253.7 nm. The AAS was also calibrated and checked for reliability and accuracy (Fig. 1) prior to the determination of Hg and Pb concentration.

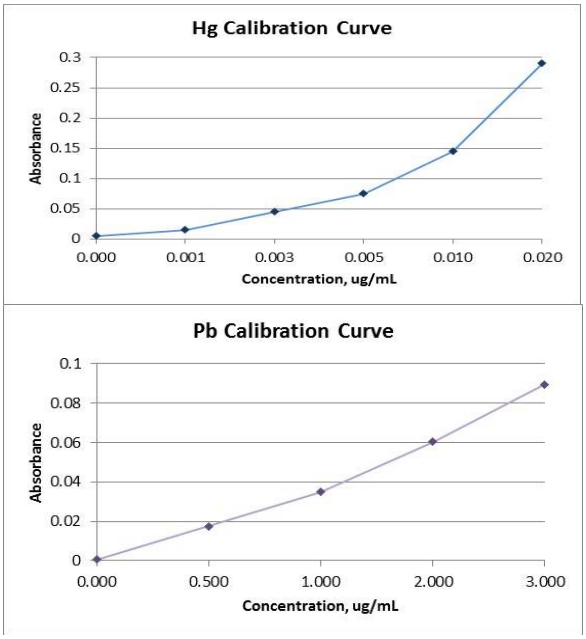


Fig. 1. Hg and Pb concentration vs absorbance curve

2.2. Household Surveys

Household surveys were conducted from December 2013 to January 2014 to gather information on what was known, believed and done in relation to Pb and Hg in ambient air of the residents in the City of Naga. Survey questionnaire was distributed to the respondents to gather valuable information on the socio-economic profile of the respondents, Knowledge, Perception and Attitudes. There were six coastal barangays, namely: Tuyan, Colon, Poblacion, Tina-an, Inuburan and Langtad chosen for the conduct of the survey. The factors considered in the selection of the chosen barangays were: it represented a location within the surrounding areas of the major pollution sources and it was accessible from the roads.

The study adapted the Slovin formula to determine the number of households surveyed for each selected barangays.

$$n = \frac{N}{1 + N(e)^2}$$

n – sample number of households
N – number of households
e – margin of error (set at 0.05)

As calculated, the total number of households surveyed for the six barangays was 382 using a margin of error of 5%. Proportionate random sampling was adapted at intervals of 5 households for densely populated barangays while 2 to 3 intervals were used for scattered households.

To facilitate the household survey, face-to-face interviews were conducted to gather the response of the respondents in terms of their Socio-demographic profile and their knowledge, attitudes and perceptions about air pollution specifically Hg and Pb in ambient air.

III. RESULTS AND DISCUSSION

3.1. Mercury and Lead Concentration in TSP

Fig.2 shows the ambient concentration of Hg in one sampling station in the City of Naga from August to December 2012 which is below the allowable limit of 5 mg/Nm^3 for stationary sources of pollution set by PCAA of 1999. Since Hg is also a heavy metal, its transport and deposition is dependent upon many variables such as meteorological conditions, other chemical pollutants emitted along with it, and the chemical make-up of the air mass [4][5]. The observed concentration of Hg could be attributed to the condition that once Hg is released into the atmosphere, it undergoes transformation which includes transitions between gaseous, aqueous and solid phases, chemical reactions in the gaseous and aqueous environment is based on the kinetic mechanism. The chemical and physical transformations of Hg include dissolution in cloud droplets, gas-phase and aqueous-phase oxidation by ozone, chlorine and hydroxyl radical, aqueous-phase reduction via decomposition of sulfite complexes, formation of chloride complexes, and adsorption by soot particles in cloud water [4].According to Lindqvist et al. [6] and [5], the water-soluble fraction and the fraction associated with particulate matter of Hg are readily removed from the atmosphere and have a residence time of perhaps a few days or weeks. Furthermore, according to [7] about 40 – 90% of heavy metals (e.g. Hg) are removed from the atmosphere with wet depositions such as rain. The mercury from industries and power plants is emitted primarily as Hg vapor. This vapor consists mainly of elemental mercury and dimethyl mercury though other Hg species can also contribute [6]. Seiler and Brosset in [6] suggest that most Hg is emitted as

dimethyl mercury with a relatively fast degradation to elemental Hg and mobilized to the atmosphere where it is subjected to atmospheric oxidation processes to yield water soluble forms, subsequently scavenged by wet and dry deposition. Thus, the sharp increase of mercury in October 1 – 2 could be explained by the high rainfall from September to October.

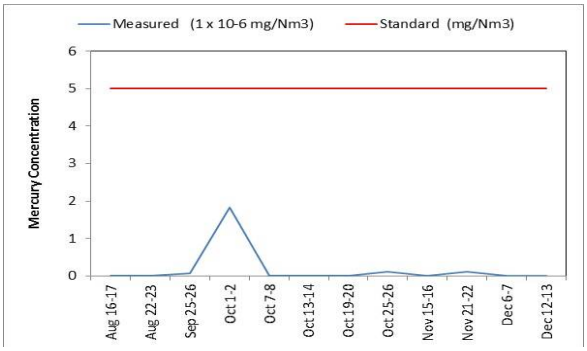


Fig. 2. Hg concentration in TSP samples in Naga City, Cebu from August to December 2012

Fig. 3 shows the concentration of Pb in 12 TSP samples is presented in Figure 9, sampled from August to December 2012 in the City of Naga. The result showed a very low level of Pb as compared to the allowable limit of 1.5 µg/Nm^3 (short term) and 1.0 µg/Nm^3 (long term) for National Ambient Air Quality Guideline for criteria pollutants or even the 10 mg/ Nm^3 for stationary sources of pollutants set by PCAA of 1999. The observed low value may be attributed to the fact that Pb was already phased-out in the fuel used by motorized vehicles and a number of published studies had revealed that Pb levels were reduced by about 25% during the period 1982 to 1995 [7]. The factor to be considered now is the use of coal in power plants as well as alternative fuels (e.g. residual wastes, rubber) in cement plant at high temperature. According to Pacyna (1987), lead in inorganic forms is widely released particularly lead oxide and lead chloride with respect to the chemical forms of Pb from these sources. A major portion of Pb emissions from high temperature sources is transported over long distances. The behavior of Pb during transport depends on its physical-chemical properties, the particle size-distribution, and meteorological conditions, such as rate of turbulent vertical exchange and wind speed. It should be noted that the City of Naga including the major pollution sources were located in proximity to the shorelines where fast dilution and dispersion of pollutants could took place.Heavy metals such as Pb are volatile, but PbCl2, elemental lead (Pb(O)) and PbO are non-volatile (Gerstle and Albrinck, 1982 as cited by [6] which would continue to be emitted largely as fly ash, even at the higher temperature. This might explains why Pb is usually abundant in submicrometer size range [6] and [8].

According to [9], the particles larger than 4 µm are responsible for 82% of the Pb deposition and only 20% of the total deposition is accounted for by particles with sizes larger than 7 µm. According also to the study of [10], 0.21% of total mass for TSP and 0.26% of total mass for PM10 are Pb particles. The average ratio of Pb concentrations in PM10 to that of TSP is 0.64±0.094, which indicates that 64% of Pb particles have a diameter less than 10 µm. The findings simply suggest that the concentration of Pb increase markedly with decreasing particle size. This might be the reason why even with the varying concentration of TSP in the samples the concentration of Pb remained fairly the same since TSP had a relatively coarse size range of up to 100 µm.

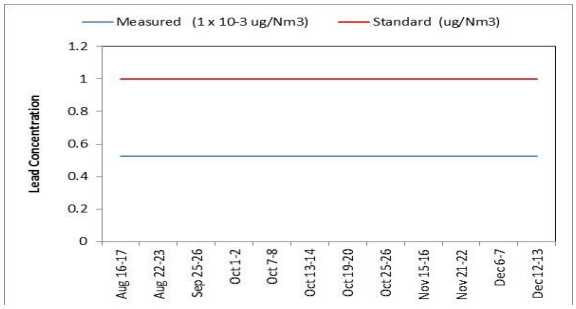


Fig. 3. Pb concentration in TSP samples in the City of Naga, Cebu from August to December 2012

3.2. Knowledge, Attitudes and Perception of the Residents

The data of the survey tend to show that the levels of knowledge of the respondents were high in general knowledge items and moderate for specific and technical items. This was manifested by the results that out of the 19 questions under knowledge, most of the respondents decided to choose “doubt” with their answers as compared to answer “false” on technical items. This may be attributed to the fact that 42% of the respondents reached secondary level and 43% of them got college education. Information-Education-Campaign may be used to strengthen the knowledge items where many respondents had doubts.

The data also showed that the residents were consistent with the general knowledge about health and air quality. They had positive attitudes and concerned to the care of their health and environment. However, they wanted to be informed of the current status of the quality of air in their community and be involved of the environmental issues around them that affect their livelihood and health.

The survey data showed that majority of the respondents strongly believed that their locality was already polluted with lead and mercury due to the presence of the industrial plants and the increased number of motorized vehicles plying around the area. They also perceived that Pb and Hg emissions/pollution were the cause of some of their illnesses. But more than half of the respondents still believed that the local government and DENR regularly implemented, monitored and checked the air quality in the city.

The results of the survey revealed that the level of knowledge, perception and attitudes of the respondents were adequate but moderate for specific and technical information about heavy metal air pollution. Their general knowledge about air pollution could probably come from mass media (television, radio, newspapers, and internet) and other sources of environmental information.

Based on the results of this study, the 2012 emission of Pb and Hg of the ambient air in the City of Naga was below the tolerable limits set by the Philippine Clean Air Act of 1999. But the survey revealed that around 78% of the respondents strongly believed that their locality was already polluted by Pb and Hg. The perception of the residents did not coincide with the laboratory results because there was a one year gap with respect to the sampling period. The TSP samples were taken from August to December 2012 while the survey was conducted from December 2013 to January 2014.

CONCLUSIONS

Based on the results of the study, the following conclusions were deduced:

1. Naga city was not yet polluted with Hg and Pb. The actual measurements from the 12 samples showed that Pb concentration remained fairly low of about 5 x 10^{-7}µg/Nm^3 while Hg has the highest concentration of 1.838 x 10^{-6}µg/Nm^3, all of these are still below the standard set by the Philippine Clean Air Act of 1999. The observed low concentrations of Pb and Hg pollutants in the area could be attributed to the ban of leaded gasoline in motorized vehicles, the kind of fuel used and the controlled-emission equipment adapted by the industrial plants in the study area to minimize pollution in the ambient air.
2. The concentration of Hg and Pb at the sampling site at different sampling periods revealed that distance, wind direction, climatic condition, location and the composition of the TSP samples had played significant role in the deposition, dilution and dispersion of pollutants. It must be noted that there was proximity of the industrial plants and the national highway of the city to the shorelines in which fast dilution and dispersion of pollutants may took place. Also, the low detection of Pb in the TSP samples which had coarse sizes of up to 100 m may be attributed to the fact that Pb concentration was observed to be more significant in the fine particulate size of up to 4 m. The high detection of Hg in certain sampling days maybe due to heavy rainfall which contributed to fast deposition of the particles and the prevailing wind direction coming from the sources to the sampling station that added to the detectable concentration of Hg.
3. The knowledge, attitude and perception levels of the household respondents towards the toxic effect of air pollutants particularly Hg and Pb were considered adequate but still require more environmental education program especially on specific and technical information about air pollution. The information-education-campaign such as seminars, symposia and open-forum may strengthen their level of knowledge, attitudes and perception about heavy metal pollution so that they can be of help in the proper management and care of the environment.

ACKNOWLEDGMENTS

We would like to thank the Department of Natral Resources and Environment – Environmental Management Bureau Region 7 (DENR-EMB7) for allowing us to use their TSP samples.

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