CHASING MERCURY:

Measuring Mercury Levels in the Air Across the Philippines

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By

Ban Toxics!

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Executive Summary

Mercury is a naturally occurring element of the earth. Mercury is also one of the most dangerous environmental pollutants. Mercury is permanent and cannot be created nor destroyed by any chemical means. It is a known neurotoxin that attacks the brain, and is most dangerous to the fetus, young children, and pregnant women. Its various forms – elemental, organic and inorganic – are all poisonous, with unique routes of exposure and toxicological behavior. Mercury is a chameleon and simply changes forms through interacting with other elements in the environment and is capable of travelling long distances through the wind currents.

The mercury situation in the Philippines is alarming. In 2008, the Environmental Management Bureau, under the Philippine Department of Environment and Natural Resources, conducted a mercury assessment for the Philippines. The report revealed a staggering annual release of 133,589 kilograms of mercury into various environmental media, with air bearing the brunt of the emissions -- 80,755 kilograms of mercury are released into the air every year. The most significant contributors are: 1) primary virgin metal production, primarily from the artisanal and small-scale gold mining sector, with 49% of emissions; 2) extraction and use of fuels and energy sources at 24%; and 3) intentional use in products and processes at 20%.

In spite of the 2008 inventory, regular monitoring and advisory of mercury and other heavy metals levels in air and other media do not receive as much attention as other common pollutants. For instance compared to NO_x and SO_x, which are easily associated with smoke belching, and CFC which is instantly linked to climate change and global warming, not to mention polystyrene packaging, gaseous heavy metals are more “exotic” and less common in everyday examples. They appear to be an “invisible” classification of air pollutants.

Mercury pollution is a major concern because background levels already exist. As long as no active measures are taken to detect these pollutants, establish a baseline, and mitigate the current levels, background levels of heavy metals in the air will quietly and steadily rise over time.

Health Effects of Mercury in Air

Elemental mercury in air is equally dangerous and capable of causing damage to the human body. Absorption of mercury by inhalation of mercury vapor is quick and complete. It is absorbed quickly through the membranes of the lungs and becomes 100% bioavailable for uptake by the bloodstream.

The St. Andrew's School mercury spill is a horrific reminder to Filipinos of the danger posed by mercury vapor inhalation. 93 students were exposed to elemental mercury during a science experiment. Of the 93, 10 students were targeted for close monitoring. Out of the 10, 1 boy succumbed to the mercury vapor in the classroom that caused him to suffer permanent Parkinsonism and nerve damage.

Long-term, low-level exposure to elemental mercury vapor, like eating food contaminated with organic mercury, affects the nervous system most adversely, causing depression, anxiety, insomnia, constant fatigue, tremor, and behavioral disturbance. On the other hand, acute high-vapor exposure directly hits the lungs. Such cases have caused irreversible damage to the lung tissue, leading to respiratory dysfunction, failure and progressing to death.

Findings and Recommendations

Within the six-month research period, BT was able to visit and monitor many varied sites in the Philippines. Following are several relevant findings based on the results and experiences of the study:

1. A background level of mercury already exists in the Philippines, even in areas with no known or alleged mercury use;
2. The highest mercury vapor concentrations were found in sites where mercury was actually being used or stored;
3. In mining areas, mercury vapor concentrations increase dramatically during operations that utilized mercury;

Photo: Luis Liwanag/SSNC

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4. A background level of mercury already exists in the Philippines, even in areas with no known or alleged mercury use;
5. The highest mercury vapor concentrations were found in sites where mercury was actually being used or stored;
6. In mining areas, mercury vapor concentrations increase dramatically during operations that utilized mercury;
7. Despite regulations from the Departments of Health and Education, many health facilities and schools still contain mercury and mercury-containing devices, either in use or improperly stored; and
8. Proper, careful packing and correct storage techniques make a big difference in reducing the amount of mercury being released into the air by elemental mercury and mercury-containing chemicals and devices.

Several recommendations can be established as a result of this investigation:

1. Reducing or eliminating man-made mercury sources;
2. Enforcement of regulations;
3. Information and awareness raising;
4. Consistent and regular monitoring;
5. Proper packaging and storage of mercury;
6. Increased attention on air pollution caused by heavy metals such as mercury; and
7. International action on eliminating man-made sources of mercury is urgently needed.

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1. Introduction/Background

Context

Just how clean is the air we breathe?

In 2007, the World Bank's Philippines Environment Monitor reported that 18 million Filipinos are exposed to air pollution in major cities across the country. In Metro Manila alone, nearly 5,000 Filipinos die prematurely every year, due to cardiovascular and respiratory diseases caused by exposure to poor air quality. Air pollution is responsible for 5% of all reported disease cases, and 4% of all reported deaths nationwide.[1]

Legislative measures have been taken to address the rising concerns regarding air quality in the country. Republic Act No. 8749, popularly known as the Clean Air Act of 1999, covers the monitoring, regulatory and implementation of all matters relating to air pollution. This includes monitoring the extent of pollution in the country based on type of pollutant and type of source, evaluating the current state, trends and projections of air pollution, identifying critical areas, and recommending the necessary executive and legislative actions.

However, not all legislation translates to complete and efficient implementation. Despite the Clean Air Act's comprehensive list of air pollutants for monitoring, attention and actions by government have consistently focused on the obvious, familiar, and visible forms of air pollution such as carbon dioxide (CO_2), chlorofluorocarbons (CFC), nitric oxides (NO_x), sulfur oxides (SO_x) and volatile organic compounds (VOCs) such as methane. However, polluted air also contains a range of other dangerous compounds – particulate matter from the burning of fossil fuels, and toxic metals such as mercury, lead, and cadmium.

Aside from the familiar pollutants Of these, heavy metals are one of the most alarming air pollutants because of three reasons: First, they are toxic by nature. Many heavy metals have been proven to have adverse effects on health, particularly to the brain, lungs, and kidneys. The most vulnerable to its ill effects are the fetus, babies and children. They also have the ability to bioaccumulate and biomagnify, and find its way into human food supply.

Second, heavy metals levels in air do not receive as much attention as other common pollutants because they are more difficult to visualize. Compared to NO_x and SO_x, which are easily associated with smoke belching, and CFC which is instantly linked to climate change and global warming, not to mention polystyrene packaging, gaseous heavy metals are more "exotic" and less common in everyday examples. They appear to be an "invisible" classification of air pollutants. Thus, less time and financial resources are allocated for detection of heavy metals in air. For example, the Environmental Management Bureau of the Department of Environment and Natural Resources does not include the concentration of heavy metals in its annual air quality monitoring report.

Finally, heavy metal air pollution is a major concern because background levels already exist. As a consequence of the previous explanation, no consistent, comprehensive monitoring of metal vapor concentration is being done. As long as no active measures are taken to detect these pollutants, establish a baseline, and mitigate the current levels, background

levels of heavy metals in the air will quietly and steadily rise over time.

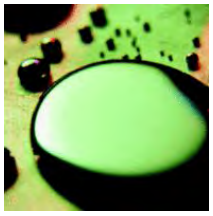
Objectives

Ban Toxics! (BT) initiated a survey of mercury levels in several areas in the Philippines as preliminary step to address the gap. With the technical assistance of the European Environment Bureau and the Zero Mercury Working Group, BT collected data with a Lumex RA-915+ mercury vapor analyzer to investigate the unacknowledged mercury air pollution in the country. The objectives of this research are the following:

1. to determine mercury concentrations in air in various chosen locations in the country;
2. to identify possible mercury vapor hotspots based on collected data;
3. to establish a preliminary background level of mercury vapor contamination in the Philippines;
4. to enhance public awareness on hidden mercury air pollution and its impacts to society; and
5. to encourage action from government, academe, related industries, civil society and other relevant stakeholders

2. Mercury

A. The Element



Mercury is a naturally occurring constituent element of the earth; as such, it can neither be created nor destroyed by any chemical means. Mercury is capable of lasting permanently in the environment. It exists in a number of forms. In its pure, elemental form, mercury is a shiny silvery liquid that easily volatilizes, or turns into vapor, at room temperature. The inorganic form, called mercury salts, consists of mercury compounded with other inorganic elements, such as nitrogen and sulfur. One example is mercuric sulfide. These are usually found in minerals and in laboratory chemicals. The organic form results when mercury combines with carbon and hydrogen to produce compounds such as methylmercury. This toxic neurotoxicant is found in contaminated fish and other seafood.

Mercury is a chemical element of concern because of its three special characteristics:

1) Mercury is a potent neurotoxin, harmful to both humans and wildlife. Significant adverse impacts on human health and the environment have been documented around the world. The Minamata tragedy in Japan, perhaps one of the biggest mercury poisoning incidents worldwide, affected generations of Minamata citizens and continues to do so today. Mercury affects the brain, affecting neurological development and activity. The fetus, newborn and young children are especially sensitive to its effects due to their developing nervous systems.

MINAMATA MERCURY POISONING

It started out quite simply, with the strangeness of cats "dancing" in the street—and sometimes collapsing and dying. Who would have known that this curious spectacle would be the precursor to one of the most horrific mercury pollution cases in the world?

Minamata is a city on the island of Kyushu in southern Japan. Between 1932 and 1956, an acetaldehyde plant owned by the Chisso Corporation released effluents into the Minamata Bay containing methylmercury, one of the most toxic forms of mercury.

In the early 1950's, people in the modest Japanese fishing village of Minamata began noticing a mysterious illness invading their community. Like the "dancing" cats similar behavior began to appear—sporadically and without much notice—in humans. People would stumble while walking, not be able to write or tremble uncontrollably.

The mysterious epidemic turned out to be methylmercury poisoning that bioaccumulated in the shellfish and fish that make up an important part of the local diet. More than 200,000 people were exposed, including residents of adjoining coastal areas and villages.

900 people died and 2,265 people were certified as having directly suffered from mercury poisoning – now known as Minamata Disease. Since then thousands have surfaced and been diagnosed with varying degrees of mercury poisoning. These Minamata victims continue their struggle for recognition from the government and survival.

2) Mercury is already present in the environment. Although geographical sources such as volcanic eruptions and weathering of rocks naturally release mercury into the environment, anthropogenic or man-made sources have produced most of the annual global mercury releases since the onset of the industrial age. Mercury is now present in various environmental media and food.

3) Mercury is persistent and cycles globally. Whatever amount or form of mercury that is released from any source easily circulates through the environment, especially through air. Mercury in air that enters the aquatic environment, may also transform from elemental mercury into organic mercury, through bacterial action, which is eaten by fish and assimilated into the food chain.

B. Mercury and Health

Mercury is one of the most toxic metals known to man. Each form of mercury has its own toxicity profile, and health effects may also vary depending on the route of exposure. Of particular concern when it comes to exposure through inhalation is the elemental form of mercury.

Organic mercury

Organic mercury is largely absorbed from contaminated food due to their solubility in lipids or fatty tissues. In fact, 90-100% of an oral dose of organic mercury is absorbed in the gastrointestinal tract, and accumulates in the kidney and the brain.[23] The most popular case of widespread methylmercury poisoning occurred in Minamata, Japan in 1956 (see info box).

During the 1970s, about 500 Iraqis died while thousands were disabled for life after eating bread made from grain seeds treated with methylmercury fungicide. Offspring of pregnant women who ate the contaminated bread during pregnancy exhibited symptoms ranging from delays in speech and motor development to mental retardation, reflex abnormalities and seizures. Guatemala and Pakistan have experienced similar poisonings.

Inorganic mercury

Inorganic mercury compounds are usually in the form of non-volatile solid salts. Thus, poisoning by inhalation is unlikely unless they are inhaled in the form of aerosols and deposited in the lungs. They are far more hazardous when absorbed through ingestion because of their solubility in the body's aqueous system. Majority of the ingested inorganic mercury accumulates in the liver and kidneys and is excreted through bile and urine. In excessive amounts, it causes bloody diarrhea which may lead to hypovolemic shock and death. Accumulation of mercury salts in the kidney may also lead to renal failure.[4]

Elemental mercury

In contrast with organic and inorganic mercury, ingestion of elemental mercury is unlikely to cause toxic effects due to the low gastrointestinal absorption rate: less than 0.01%, meaning a 70 kg man will need to ingest more than 100 g in a single dose to experience toxic effects. Absorption by dermal contact is also low at approximately 2%.

On the other hand, absorption by inhalation is quick and complete. Once it is absorbed quickly through the alveolar membrane in the lungs, the mercury becomes 100% bioavailable, with a portion being taken up by the red blood cells, and the rest being distributed to various organs through the bloodstream. Mercury that is taken up by red blood cells is converted to inorganic mercury (II) oxide. Majority of the body's mercury load is excreted via urine, with a half-life

of 30-60 days. Mercury that has accumulated in the brain, by comparison, has a half-life of more than several years.[5]

Toxicity of mercury vapor is dependent on dosage. For high-level acute exposure, symptoms such as cough, chest tightness, fever and pneumonitis may manifest after 3-5 hours, leading to respiratory disease. Central nervous symptoms such as tremor and behavioral disturbance may also manifest if exposure levels are sufficiently high, and especially when repeated exposures result in accumulation of mercury in the body.

Health Impacts of Inhaling Elemental Mercury Vapors

The effects of inhalation of elemental mercury vapors have been documented in a number of case studies. A clinical and histological research on acute mercury vapor inhalation published in 1991 showed that unlike long-term, low-level exposure, which primarily affects the neurological system, acute exposure to high levels of mercury involve the lungs.[6] The patients, who inhaled large amounts of mercury vapor upon attempting to extract silver from mercury amalgam, followed similar courses of progressive respiratory failure leading to death. Despite reduction in blood mercury levels achieved through chelation therapy, damage to the lung tissue was complete, with no reversal in the progression of lung injury and respiratory dysfunction.[7]

A 2003 study in the International Journal of Hygiene and Environmental Health showcased exposure to mercury in the industrial and residential settings.[8] One 45-year old woman working in the assembly of mercury thermometers experienced neurologic symptoms such as depression, anxiety and insomnia, sensitivity to light and constant fatigue after working for approximately 2 years in the factory. Collected air samples revealed an elemental mercury vapor concentration of 300,000 ng/m^3 – three times the maximum limit set by the US Occupational Safety and Health Administration. Her case was linked to elemental mercury intoxication, and referred to the United States Agency for Toxic Substances and Disease Registry.

In the Philippines, a number of students from the St. Andrew's School of Parañaque were exposed to 50 grams of elemental mercury after a mercury spill allegedly occurred in their class in February 2006. The affected students experienced fever, itchy rashes, difficulty in breathing, chest pain and body malaise. Ninety-three were brought in for screening. Of the 93, 10 were pinpointed for close monitoring, and of the 10, 1 student succumbed to adverse impacts of mercury vapor. The child was diagnosed to have exhibited Parkinsonism and nerve damage due to acute mercury vapor inhalation.

Philippine studies on mercury and its effects

Several studies have been conducted to probe the effects and impacts of mercury pollution in the Philippines.

In 2008, a report which summarizes more than 30 years of fish mercury research in Davao gulf, showed that mercury lowers children's IQ levels for life. The report also demonstrated that fetuses and babies are particularly harmed by mercury in fish.

In 2007, a paper presented during a scientific conference in Davao City revealed that mercury- tainted water from Diwalwal mining site which drains into the Agusan River poses a serious threat to the inhabitants. It was also reported that tests made on weekly diets of rice, fish and mussels of people in mining areas revealed the presence of mercury three times over the permissible levels.

In September 2006, the Department of Health presented in the conference on Chemical Safety for Sustainable Development in Budapest, Hungary the health and environmental risk assessment made among communities near an abandoned mercury mine especially those whose diet includes consumption of marine or aquatic products. The study was carried out in Honda Bay and Palawan Bay and in villages near an abandoned mine that was in operation for more than 20 years. The assessment unveiled the following:

a. Four (4) fish species had exceeded the recommended total mercury and methylmercury levels in fish while two (2) fish species namely saging and kanuping had exceeded the permissible levels for methylmercury.

b. While total and methylmercury in canned fish, total mercury in rice, ambient air and drinking water were within the recommended levels, additional mercury load from these sources may contribute to the over-all body burden of mercury among residents in the area.

c. Surface water quality at the mining area, Honda Bay and Palawan Bay exceeded total mercury standards at NV>0.002 ng/ml.

d. Soil samples in Tagburos village and Honda Bay exceeded the EPA Region 9 Primary Remediation Goal recommended values for total mercury for residential purposes at NV>23 mg/kg.

e. Statistically significant results were obtained for infants when comparing the methylmercury levels in hair for both exposed and control sub-groups. Likewise, comparing the initial and final hair methylmercury levels among pregnant women/mothers in the exposed group showed statistically significant ($p<0.05$) results. Comparing the exposed and control sub-groups' mercury hair levels per sub-group showed statistically significant results among the following; (a) initial and final total mercury hair levels among children, (b) initial and final methylmercury hair levels among children, (c) final total mercury hair levels among pregnant women, (d) initial and final total mercury hair levels among mothers, and (e) initial and final methyl hair levels among mothers.

A 2005 study made by the Davao Regional Office of the Department of Health (DOH) estimated that 13.5 metric tons of toxic mercury from ASGM flow annually thru rivers into the Davao Gulf. Examination of fish samples from Davao Oriental, Davao del Sur and Davao City markets also revealed that they have mercury contents higher than the allowable limit of 0.3 microgram per gram.

In 2000, a study was commissioned by the United Nations Industrial Development Organization (UNIDO) to investigate the effects of mercury contamination in regions affected by the mining operations in Diwalwal, Monkayo, Compostella Valley.

Part of the study commissioned by UNIDO was the examination of the mine workers from Diwalwal and in the impact barangays in the lowland area of Monkayo. The miners were found to exhibit severe symptoms of mercury intoxication such as fatigue, tremor, memory problems, restlessness, loss of weight, metallic taste and sleeping disturbances. People from the lowland area of Monkayo and surrounding barangays, on the other hand, complained of headache, vision problems and nausea, other symptoms which could be related to mercury. Of the workers tested, 55 percent of the ball-mill workers and 61 percent of the amalgam smelters were

found to have mercury levels above toxicological threshold limits.

The finding of the UNIDO study in the Naboc River Basin was later re-confirmed by the assessment carried out by the Department of Environment and Natural Resources in 2009. According to its report on the geological and bio-physical characteristics of the Naboc River Basin, the water quality of the watershed is categorically critical because of its high mercury content.

In February 2000, Dr. Hirokatsu Akagi of the National Institute for Minamata Disease (NIMD) collected blood specimen samples from 49 residents of Aroroy, Masbate to determine mercury levels in their bodies. Results of laboratory examination showed that 35 out of 49 or about 71 percent have elevated mercury level which is beyond the normal level of 6.5µg/l.

C. Gaining Public Health and Environmental Attention

Mercury has become an increasingly popular chemical of concern over the last several years, both on the local and international levels. A comprehensive global treaty on the reduction of mercury releases to protect human health and the environment, organized and developed by the United Nations Environment Programme (UNEP), was agreed to be undertaken by 140 countries in a historic UNEP Governing Council decision in 2009. It aims to reduce mercury supply and demand, and boost capacity for safe storage of mercury stockpiles, among others.[9] As of this writing, two sessions of the Intergovernmental Negotiating Committee (INC) have concluded – INC1 in Stockholm, Sweden, and INC2 in Chiba, Japan. UNEP aims to adopt the treaty in 2013 after five more global negotiating sessions.[10]

In the Philippines, recent events such as the infamous mercury spill incident in St. Andrew's School, Parañaque, have put mercury in the spotlight of legislators, the health sector, and consumer watchdogs. Concern over mercury prompted the Department of Health, after prodding from NGOs, particularly HealthCare Without Harm Southeast Asia, to issue Administrative Order No. 21 in 2008, mandating the gradual nationwide phase-out of all mercury-containing devices from all healthcare facilities. Following suit, the Department of Education issued Memorandum No. 160 in 2010, recommending a review of existing department regulations to ensure the exclusion of mercury among the commonly used chemicals in school science laboratories and calling the attention of school administrators to DOH AO 21.

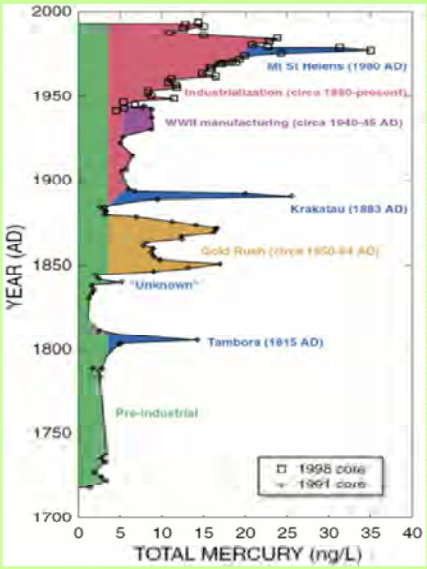
The rampant and heavy use of mercury in artisanal and small-scale gold mining (ASGM) took center stage in December 2010. The United Nations Environment Programme held a global forum on Artisanal and Small-Scale Gold Mining to highlight the continued dangers of mercury-use in the sector and the presence of mercury-free alternatives. Senator Miguel Zubiri, Chair of the Senate Committee on Environment, delivered a privilege speech calling for a need to examine current mercury-using mining practices in ASGM.

Photo: Luis Liwanag/SSNC

In January 2011, Ban Toxics visited the province of Romblon through the invitation of Governor Eduardo Firmalo for a consultative forum on mining with government agencies, officials, and small-scale miners. Part of the consultation included mercury vapor testing in various locations around the province, especially in gold-processing sites that use mercury. The findings prompted Gov. Firmalo to issue Executive Order No. 1, s. 2011, mandating an indefinite moratorium in the exploration, excavation, extraction, and utilization of metallic minerals in Romblon. This ban is to be lifted only when all issues and concerns raised by the different sectors and inhabitants of the local community have been genuinely addressed.[11]

3. Global mercury levels

Efforts have been taken to assess and put solid figures on mercury use, demand, and emissions around the globe. The United Nations Environment Programme (UNEP) released its Global Mercury Assessment in 2002 (UNEP Report), citing information and comments submitted by 81 countries in Africa, Asia, Europe, Latin America and the Caribbean, Near East, North America and the Southwest Pacific.[12]



MERCURY: A CHILLY MATTER

Scientists from the United States Geological Society conducted studies of ice core found in the glacial ice of Wyoming, where they found historical patterns of atmospheric mercury deposition preserved in glacial ice.

During the past 270 years, volcanic events contributed 6 percent of total atmospheric mercury input, while other natural background sources contributed 42 percent. The percent of total mercury emission from human sources increased from about 41 percent in the first 170 years (the majority of which was from the 19th century gold rush) to 70 percent during the last 100 years.

Several significant findings emphasize the reality of mercury pollution as a global problem.

Global cycling of mercury aggravates the problem, as both local mercury releases and the significant general global background mercury concentration contribute to the mercury burden in virtually any area. Despite the decreased use of mercury in many industrialized countries, developing nations such as the Philippines lag behind because of outdated technology, less comprehensive and weaker legislation, and the continued environmentally unsound use of cheap and easily available mercury. Although export bans on mercury are soon to be in place, global trade still allows numerous industries and sectors to continue using mercury in its products and processes.

The UNEP Report estimates that 1.9 million kilograms of mercury were released in 1995 from a number of major anthropogenic sources. Approximately 70% of this volume is elemental mercury coming from the combustion of fossil fuels such as coal, and incineration of waste materials.

A 2009 study published in the Journal of Environmental Science & Technology projected an increase in annual mercury emissions due to socioeconomic and technological development. In particular, the expansion of coal-driven electricity generation in Asia is expected to contribute to the estimated mercury emissions of 2.39 million to 4.86 million kilograms per year by the year 2050.[13]

4. Local mercury situation

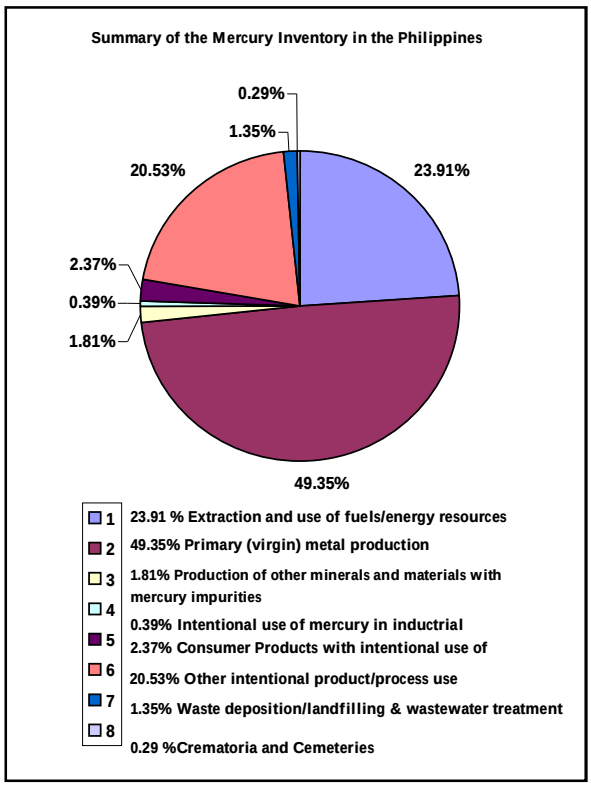
The mercury pollution in the Philippines is alarming. In 2008, the Environmental Management Bureau, under the Philippine Department of Environment and Natural Resources, conducted a mercury assessment for the Philippines. The report, which follows the assessment toolkit provided by UNEP, contains a list of all known main and sub-categories of mercury sources in the Philippines and the estimated annual releases from each category.

The report revealed a staggering annual release of 133,589 kilograms of mercury into various environmental media. The most significant contributor came from primary virgin metal production or primarily from the artisanal and small-scale gold mining sector, producing over 49% of the total emissions with 65,928 kg/year. Following are the extraction and use of fuels and energy sources at 31,940 kg/year (24%) and intentional use in products and processes at 27,431 kg/year (20%).

According to the study, air bears the brunt of these mercury emissions among all environmental media. 80,755 kilograms are released to the air annually. Land is a far second with 16,784 kg/year, followed by water with 15,695 kg/year.

The huge volume of mercury being released into the air should be a priority issue among concerned government agencies, civil society organizations and even ordinary citizens, because this form of pollution is most likely to go unnoticed until contamination levels have nearly exceeded the ceiling level set by local authorities. As highlighted in UNEP's 2002 Global Mercury Assessment, a significant factor in the mercury problem is its ability to travel a wide distance from its origin, thereby contributing to the global background mercury level.

With the considerable amount of mercury being released into the air annually by sources within the Philippines as well as outside of the country, mercury pollution can happen in areas where there is no visible source of mercury. For example, mercury that is released in a mining area can migrate to schools or homes many kilometers away. Meanwhile, the residents and students have no idea that they may be breathing elevated mercury levels in air.



5. Lumex RA-915+ Mercury Spectrometer

The Lumex RA-915+ is a mercury spectrophotometer manufactured by Lumex Ltd., a member of the Russia-based LUMEX Group of Companies which focuses on manufacturing high quality analytical equipment. This instrument detects and measures the amount of elemental mercury vapor in the air. It is an extremely sensitive device, measuring mercury vapor concentrations that are as low as 2 nanograms per cubic meter (ng/m^3).

The nanogram is a very small unit of measurement; there are 1 billion nanograms in every 1 gram. To visualize, 1 ng/m^3 is roughly equivalent to a single drop of water in 50 million jumbo-size balikbayan boxes.

The Lumex is a popular apparatus for a wide range of environmental monitoring applications in Europe and the United States. Listed here is a small selection of mercury vapor analysis applications performed in the United States:

- 2001: The US Department of Energy used the Lumex in its research on the removal of mercury from coal combustion flue gas, to be implemented for coal-fired power plants.
- 2007: The University of Nevada's Department of Natural Resources and Environmental Science published a research on the monitoring of active metals mines as a source of mercury pollution.
- 2008: The Department of Environment in Maine produced a revised guide for clean-up procedures for broken compact fluorescent lamps using the Lumex.

Locally, a similar Lumex machine was used during the clean-up and monitoring procedures following the 2006 mercury spill incident in St. Andrew's School in Parañaque City. There are only four Lumex units in the country as of this writing. All units are government-owned, belonging to the Department of Health through East Avenue Medical Center, the Department of Environment and Natural Resources through the Environmental Management Bureau, the Department of Labor and Employment through the Occupational Safety and Health Center, and the city of Parañaque.

The Lumex is also capable of testing mercury concentration in water, soil and other media; however, these media require special attachments. For the purposes of this investigation, only mercury in air was detected and quantified.

BT's Lumex unit was brought to various areas around the country, including mining areas, dumpsites, schools, hospitals, and other popular places around Metro Manila and nearby environs. Locations were chosen based on two major criteria. First, BT chose sampling sites that are in or near locations with known or reported mercury use. These include mining communities and areas near coal-fired power plants. Second, BT chose common populated sites and landmarks, with the goal of providing a picture of the small amount of mercury exposure we experience in a typical day. These sites include schools, hospitals, public parks, major roads, government offices and shopping malls.

6. Methodology

A. Preparatory steps

Before each sample collection, the Lumex was allowed to warm-up using the machine's baseline function. This also allowed us to check for any background mercury contamination in the area. If the preliminary reading is slightly elevated, another warm-up was conducted in an open, well-ventilated area to ensure that the baseline for the readings is as close to zero as possible for less interference with the actual data collected at the sampling site.

B. Data collection

The Lumex collects real-time readings continuously. A reading is taken every second, and readings are averaged over every period of ten seconds. For extended monitoring periods, the accompanying DataLogger software was used for convenience. This program logs all readings for a pre-set monitoring period.

For our monitoring, BT used a default monitoring period of 10 minutes. This was used for most of the sampling sites, except when extended monitoring was not possible (i.e., for sites where greatly elevated mercury levels might affect the machine, for security reasons, etc.). The machine was placed in the center of the sampling area and allowed to run for the pre-set monitoring period. To address the problem of large sampling sites, multiple points were sampled in the specified site (multi-point monitoring).

The amount of mercury vapor detected by the Lumex is dependent not only on the actual amount of mercury in the area, but on weather and climate factors as well.

Temperature

In general, the Lumex will be able to detect a higher concentration of mercury in areas with higher temperature. Heat causes mercury to volatilize or evaporate more easily, meaning that mercury vapor will be more "available" for the machine to detect. The Lumex, however, does not necessarily depend on higher temperatures to pick up any mercury reading. As long as mercury is present in the air the Lumex analyzer is able to pick this up.

Wind Direction and Speed

If the wind is blowing the ambient air away from the input hose of the Lumex, rather than towards the input hose, this may result in a lower concentration detected. Similarly, wind traveling at high speeds may result in lower readings.

Other climactic factors such as humidity and air pressure have also been seen to affect the readings.

A Kestrel 4500 Pocket Weather Tracker was used to record the atmospheric conditions during the sampling periods.

C. Data processing

Data is retrieved from the Lumex using the DataLogger software. For each monitoring, the program produces a graph plotting the instantaneous mercury vapor concentration per second for the entire period. The minimum, maximum, and average mercury concentration is also given automatically.

7. Results and Observations

The sampling sites were classified according into the following categories: coal ash, mining, schools, hospitals, dumpsites, government offices, main thoroughfares, communities near industrial parks, and others. The last category is composed mostly of common places of business and recreation, including parks, shopping malls, and embassies. Sampling with the DataLogger took place from July 2010 to January 2011.

A. Coal-Ash

BT conducted a mercury vapor analysis at or near areas that contain coal-ash. Mercury is found in coal, thus BT sought to verify mercury levels around an area where there is a high level of coal use. BT visited Naga City, Cebu for this exercise, which is situated approximately 22 kilometers away to the south of Cebu City, one of the major cities in the Visayas region of the Philippines.

The City of Naga, Cebu is the home to the SPC (Salcon Power Corporation) coal-fired power plant situated on a 30 hectare site in Colon, Naga and the soon to be operational KEPCO SPC coal-fired power plant.

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Below is a table of the results of BT's sampling around the coal-fired power plant area.

Location	Sampling date/ Time	Average reading	Maximum reading
Naga City plaza	September 24, 2010 1:47 PM - 1:57 PM	944.5 ng/m^3	1,444.7 ng/m^3
Coal ash landfill area	September 24, 2010 2:25 PM – 2:35 PM	982.4 ng/m^3	2,152.7 ng/m^3
Stockpile of recovered coal area	September 24, 2010 2:50 PM – 2:55 PM	12.7 ng/m^3	36.2 ng/m^3
Brgy. Colon area	September 24, 2010 3:00 PM – 3:10 PM	573.8 ng/m^3	2,572.3 ng/m^3

B. Mining Areas

1. Benguet

Gold mining in Benguet is said to have commenced even before the arrival of the Spaniards. For more than 400 years, the indigenous people have been practicing traditional small-scale mining. In the 1970s however, mercury use proliferated in the area when miners, then working with large mining companies resorted to high-grading by mixing mercury with concentrates.

Mining and farming remain to be the main sources of income in the province. About 40 percent of the people rely on gold mining while the other 60 percent are involved in agriculture, tourism and other industries. Itogon, Benguet is the center of small-scale gold mining activities in Benguet. It is host to Benguet Mining Corporation, a large mining company.

There are approximately 2,000 miners in the Acupan mining village in Itogon. BT visited several mining sites, and table below summarizes the result of the mercury vapor analysis in the areas visited.

Location	Sampling date/Time	Average reading	Maximum reading
Ball Mill Plant,	November 21, 2010 8:41 am -8:51am	19.2 ng/m³	30.4 ng/m³
Top-Hill Panning Area	November 21, 2010 9:15am-9:25am	92.4 ng/m³	710.7 ng/m³
Retail Store	November 21, 2010 9:59am-10:07am	18.1 ng/m³	33.0 ng/m³
Miners Barracks	November 21, 2010 3:45pm-3:55pm	3,751.8 ng/m³	30,000.0 ng/m³
Field Test	November 22, 2010 10:21am-10:31am	6.3 ng/m³	7.7 ng/m³
Ball Mill Plant with Women Miners	November 22, 2010 3:44am-3:54am	3.44 ng/m³	17.3 ng/m³
Lime Process Area	November 22, 2010 3:59pm-4:09pm	26.3 ng/m³	41.0 ng/m³
Cyanidation Area	November 22, 2010 4:12pm-4:22pm	8.9 ng/m³	10.4 ng/m³
Carbon-in-Leach Area	November 22, 2010 4:24pm-4:29pm	26.5 ng/m³	64.7 ng/m³

2. Camarines Norte

Camarines Norte is a province of the Philippines located in the Bicol Region in Luzon. Its capital is Daet and the province borders Quezon to the west and Camarines Sur to the south. Camarines Norte has a population of 513,785 based on 2007 census. The four major manufacturing and processing industries in the province are jewelry craft, gifts/toys/housewares, pineapple and coconut industry. Camarines Norte is also known for gold mining. It is one of the acknowledged centers of small-scale gold-mining in the Philippines.

Small-scale miners in Camarines Norte use large quantities of mercury in their gold-processing operations. BT was able to visit several villages in Camarines Norte to check on the levels of mercury vapor

Location	Sampling date/time	Average reading	Maximum reading
Brgy.Malaguit Residential Area	November 24, 2010 9:33am-9:44am	266.7 ng/m³	5,516.2 ng/m³
Mangrove Forest	November 24, 2010 9:58am-10:08am	9.0 ng/m³	19.7 ng/m³
Gold processing Area	November 24, 2010 10:57am-11:05am	14,275.3 ng/m³	30,000.0 ng/m³
Compressor mining area	November 24, 2010 11:29am -11:38am	93.2 ng/m³	96.4 ng/m³
Actual amalgamation	November 24, 2010 3:35pm-3:44pm	7,548.5 ng/ m³	30,000.0 ng/m³
Brgy. Hall-Tugos, Paracale	November 25, 2010 6:09am-6:18am	78.8 ng/m³	86.9 ng/m³
Tunnel area	November 25, 2010 11:17am-11:26am	17.8 ng/m³	142.7 ng/m³
Ball Mill and Panning Area	November 25, 2010 12:25nn-12:29nn	227.0 ng/m³	620.4 ng/m³

3. Romblon

The province of Romblon is situated at the center of the Philippine Archipelago. It is composed of three major islands (Tablas, Sibuyan and Romblon) and seventeen minor and small islands. It is surrounded by deep waters, and is bounded by the islands of Masbate in the east, Mindoro in the west, Marinduque in the north and Panay in the south.

As of Census 2007, Romblon has a population of 279,774. Agriculture is still the primary industry in the islands. However, the presence of gold which is mostly found in the municipality of Magdiwang in Sibuyan Island, has created a lucrative small-scale mining sector. Unfortunately, the small-scale miners are heavy users of mercury in processing their gold ores. Below are the results of the mercury vapor analysis in several areas around the island of Sibuyan, Romblon province.

Location	Sampling Date/Time	Average Reading	Maximum Reading
Dulangan river *Baseline test*	January 6, 2011 4:20 PM – 4:26 PM	12.3 ng/m^3	18.4 ng/m^3
Dulangan river *Junction of clear and muddy water*	January 6, 2011 4:34 PM – 4:40 PM	94.0 ng/m^3	157 ng/m^3
Brgy. Dulangan *Water tailings from ball mill plant*	January 6, 2011 4:46 PM – 4:54 PM	200.0 ng/m^3	3,731.4 ng/m^3
Brgy. Dulangan creek *Near the ball mill plant*	January 6, 2011 5:00 PM – 5:08 PM	23.8 ng/m^3	1,625.2 ng/m^3
Brgy. Dulangan *Tailings stock pile*	January 6, 2011 5:12 PM – 5:18 PM	382.2 ng/m^3	93.0 ng/m^3
Brgy. Tagkayo *Abandoned mine field*	January 7, 2011 10:34 AM – 10:40 AM	176.8 ng/m^3	1,715.6 ng/m^3
Brgy. Tagkayo *Open pit miners barracks*	January 7, 2011 10:50 AM – 10:58 AM	10,196.2 ng/m^3	> 30,000.0 ng/m^3
Brgy. Tagkayo *Panning area*	January 7, 2011 11:10 AM – 11:16 AM	1,290.4 ng/m^3	19,010.7 ng/m^3
Brgy. Tagkayo *Rice field*	January 7, 2011 11:50 AM – 11:56 AM	88.6 ng/m^3	421.3 ng/m^3
Brgy. Ipil *Creek; actual Hg and gold recovery from the river*	January 8, 2011 9:54 AM – 10:02 AM	819.3 ng/m^3	5,474.1 ng/m^3
Abandoned mining area	January 8, 2011 10:06 AM – 10:14 AM	10.3 ng/m^3	80.0 ng/m^3
Feeder Road	January 8, 2011 10:34 AM – 10:42 AM	5.9 ng/m^3	59.1 ng/m^3

Location	Sampling Date/Time	Average Reading	Maximum Reading
Brgy. Ipil *Residential area - baseline test*	January 8, 2011 9:38 AM – 9:44 AM	82.7 ng/m^3	588.2 ng/m^3
Brgy. Mabulo *Residential area - baseline test*	January 9, 2011 7:54 AM – 8:02 AM	24.1 ng/m^3	54.7 ng/m^3
Brgy. Espana – *Residential area – baseline test*	January 9, 2011 8:50 AM – 8:56 AM	13.6 ng/m^3	45.7 ng/m^3

Location	Sampling Date/ Time	Average Reading	Maximum Reading
Brgy. Tagkayo *Baseline test*	January 7, 2011 9:51 AM – 9:59 AM	5.2 ng/m^3	6.3 ng/m^3
Brgy. Ipil *Baseline test*	January 8, 2011 10:46 AM – 10: 52 AM	6.8 ng/m^3	75.8 ng/m^3
Brgy. Espana *Baseline test along the road*	January 9, 2011 8:36 AM – 8:44 AM	14.4 ng/m^3	58.5 ng/m^3
Magdiwang Poblacion *Waiting area*	January 7, 2011 2:18 PM – 2:26 PM	7.9 ng/m^3	64.7 ng/m^3
Magdiwang Poblacion *1st baseline test*	January 8, 2011 12:56PM - 1:04 PM	229.6 ng/m^3	2,846.0 ng/m^3
Magdiwang Poblacion *2nd baseline test*	January 9, 2011 10:04 AM – 10:10 AM	617.4 ng/m^3	2,914.9 ng/m^3
Magdiwang *Sanctuary Resort – baseline test*	January 6, 2011 3:48 PM – 3:54 PM	23.3 ng/m^3	57.8 ng/m^3
Magdiwang *Sanctuary Resort – river side*	January 8, 2011 5:28 PM – 5:36 PM	23.1 ng/m^3	28.8 ng/m^3
Kantingas River *Baseline test*	January 9, 2011 7:42 AM – 7:50 AM	15.5 ng/m^3	66.4 ng/m^3
Brgy. Mabulo Bridge	January 9, 2011 8:23 AM – 8:27 AM	19.5 ng/m^3	70.3 ng/m^3
Brgy. Tagkayo *Elementary school - baseline test*	January 7, 2011 12:20 PM – 12:28 PM	107.3 ng/m^3	211.0 ng/m^3
Romblon Provincial Capitol *Baseline test*	January 9, 2011 5:03 PM – 5:10 PM	17.4 ng/m^3	25.7 ng/m^3

4. Palawan

Palawan is an island province in the southwest of the Philippines. Its capital is Puerto Princesa City, and it is the largest province in the country in terms of total area of jurisdiction. The islands of Palawan stretch from Mindoro in the northeast to Borneo in the southwest. This province is generally considered one of the best tourist spots within the south and southeastern part of Asia.

Palawan is known for its rich biodiversity and is internationally recognized for protecting and developing two main attractions, namely the Puerto Princesa Subterranean River National Park and the Tubbataha Reef National Marine Park, which were recently named to be part of the World Heritage Sites of the United Nations Educational, Scientific and Cultural Organisation or UNESCO.

Palawan is also the site for the last mercury mine in the Philippines. From 1953 to 1976 the Palawan Quicksilver Mining Incorporated (PQMI) removed 2,900 tons of mercury from the area. The mine has since closed, but the red earth from the mines is still evident. The former mine has now been converted into a landfill, and tailings from the old mine were used to build a wharf along Honda Bay.

BT visited the village of Pulang Lupa, where the mine was located and the Sta. Lourdes wharf where the tailings from PQMI were dumped.

Location	Sampling date/time	Average reading	Maximum reading
Puerto Princesa - Sta. Lourdes Port Area	January 14, 2011 11:08 AM – 11:16 AM	13.4 ng/m^3	22.2 ng/m^3
Sta. Lourdes Sea Warf	January 14, 2011 11:19 AM – 11:27 AM	25.5 ng/m^3	105.2 ng/m^3
Honda bay Residential area	January 14, 2011 12:16 PM – 12:22 PM	24.6 ng/m^3	48.8 ng/m^3
Honda bay Hg stockpile	January 14, 2011 12:32 PM – 12:41 PM	125.0 ng/m^3	1,093.8 ng/m^3
Sitio Pulang Lupa Hg mine site	January 14, 2011 1:57 PM – 2:05 PM	299.7 ng/m^3	1,488.8 ng/m^3
Baseline test Pulang Lupa residential area	January 14, 2011 2:11 PM – 2:19 PM	21.8 ng/m^3	107.7 ng/m^3
New site of Puerto Princesa hospital dumpsite	January 14, 2011 2:45 PM – 2:54 PM	6.2 ng/m^3	12.0 ng/m^3
Inside of sanitary landfill area	January 14, 2011 3:00 PM – 3:09 PM	69.0 ng/m^3	218.2 ng/m^3
Field test Pulang Lupa elementary school	January 14, 2011 3:18 PM – 3:26 PM	4.1 ng/m^3	18.4 ng/m^3

C. Schools

With the infamy surrounding the St. Andrew's School of Parañaque mercury spill incident, BT decided to approach several schools in Metro Manila and in Cebu to test for mercury levels in their laboratories. Common in all the schools is the presence of mercury, in its elemental form and inorganic forms, as compounds in reagents. Mercury was also present in measuring equipments such as thermometers and barometers.

In order to gain access into these institutions and be able to publicize the results, BT agreed to refrain disclosing the names of the schools in this Report.

It must be noted that one school registered high levels of mercury in the air due to a broken mercuric barometer contained in the lab. BT has since advised the school to take the proper packaging and storage of the broken barometer to eliminate the mercury source in the laboratory.

1. High School A

Location	Sampling date/Time	Average reading	Maximum reading
Chemistry lab 1	November 13, 2010 10:14 AM – 10:20 AM	10.3 ng/m^3	15.0 ng/m^3
Chemistry lab 2	November 13, 2010 10:24 AM – 10:32 AM	9.6 ng/m^3	16.6 ng/m^3
Chemistry lab stockroom	November 13, 2010 10:36 AM – 10:44 AM	0.4 ng/m^3	2.2 ng/m^3
Physics lab	November 13, 2010 10:50 AM – 10:56 AM	4.4 ng/m^3	9.6 ng/m^3
Stockroom	November 13, 2010 11:02 AM – 11:10 AM	5.4 ng/m^3	7.5 ng/m^3
Main building, in front of school clinic	November 13, 2010 11:16 AM – 11:24 AM	17.8 ng/m^3	82.1 ng/m^3
Principal's office – outside	November 13, 2010 11:36 AM – 11:44 AM	4.2 ng/m^3	6.4 ng/m^3
Principal's office – inside	November 13, 2010 12:08 NN – 12:16 NN	2.6 ng/m^3	5.1 ng/m^3

2. High School B

Location	Sampling date/Time	Average reading	Maximum reading
Chemistry Lab	October 13, 2010 4:28 PM - 4:34 PM	46.5 ng/m^3	164.6 ng/m^3
Chemistry Lab/Cabinet with Hg bottled storage	November 21, 2010 4:40 PM – 4:48 PM	360.7 ng/m^3	2,086.0 ng/m^3

3. High School C

Location	Sampling date/Time	Average reading	Maximum reading
High school chem. lab	December 16, 2010 10:18 AM – 10:26 AM	84.6 ng/m^3	2,979.3 ng/m^3
Gymnasium	December 16, 2010 10:30 AM – 10:36 AM	8.3 ng/m^3	8.6 ng/m^3
Audio visual room	December 16, 2010 10:42 AM – 10:50 AM	23.3 ng/m^3	78.8 ng/m^3
2nd floor stairway/main building	December 16,2010 10:54 AM – 11:02 AM	24.6 ng/m^3	47.8 ng/m^3

4. High School D

Location	Sampling date/Time	Average reading	Maximum reading
Physics lab stockroom	January 13, 2011 10:08 AM – 10:17 AM	6.8 ng/m^3	12.5 ng/m^3
Garbage disposal area	January 13, 2011 10:31AM – 10:39 AM	19.0 ng/m^3	79.2 ng/m^3
Chemistry lab stockroom	January 13, 2011 10:48AM – 10:57 AM	5.3 ng/m^3	35.4 ng/m^3
Chemistry lab stockroom – fume hood with mercury	January 13, 2011 11:00 AM – 11:08 AM	16.0 ng/m^3	50.0 ng/m^3
IS lab stockroom	January 15, 2011 11:15 AM – 11:23 AM	8.3 ng/m^3	19.9 ng/m^3

5. College A

Location	Sampling date/Time	Average reading	Maximum reading
College lab	September 23, 2010 10:23 AM – 10: 33 AM	2,442.2 ng/m^3	6,760.9 ng/m^3
College chem lab	September 23, 2010 11:10 AM – 11:15 AM	75.1 ng/m^3	166.7 ng/m^3
HS chem lab	September 23, 2010 11:44 AM – 11:54 AM	9,956.6 ng/m^3	> 30,000 ng/m^3
Physics room	September 23, 2010 1:19 PM – 1:29 PM	111.8 ng/m^3	848.3 ng/m^3
Ground floor lab	September 23, 2010 1:35 PM – 1:45 PM	196.2 ng/m^3	206.2 ng/m^3

6. High School E

Location	Sampling Date / Time	Average Reading	Maximum Reading
High School dept.- Chem Lab	November 22, 2010 3:45 PM – 3:54 PM	12.7 ng/m^3	17.3 ng/m^3
High School dept.- Physics Lab	November 22, 2010 3:45 PM – 3:54 PM	26.3 ng/m^3	41.0 ng/m^3
Stockroom High School Building	November 22, 2010 4:14 PM – 4:22 PM	8.9 ng/m^3	10.4 ng/m^3
Clinic With Sphygmometer	November 22, 2010 4:26 PM – 4:29 PM	26.5 ng/m^3	64.7 ng/m^3

7. High School F

Location	Sampling Date / Time	Average Reading	Maximum Reading
Biology laboratory	July 29, 2010	93.2 ng/m^3	96.4 ng/m^3
Chemistry laboratory	July 29, 2010	92.4 ng/m^3	710.7 ng/m^3
Physics laboratory	July 29, 2010	78.8 ng/m^3	86.9 ng/m^3
Temporary lab stockroom – general	July 29, 2010	227.0 ng/m^3	620.4 ng/m^3
Temporary lab stockroom – near broken mercury barometer	July 29, 2010	19.2 ng/m^3	30.4 ng/m^3
School clinic	July 29, 2010	570.4 ng/m^3	1,911.8 ng/m^3

D. Hospitals

Other mercury source points are hospitals and healthcare facilities. Mercury in these institutions is found in measuring devices such as thermometers and sphymomanometers. BT was granted access by one hospital under a non-disclosure condition. BT measured mercury levels in various areas of the hospital from the dental clinic to the non-operational garbage incineration unit where end-of-life fluorescent bulbs are stored. Below are the results of BT's analysis.

Of note are the levels found in the storage are where mercury thermometers were placed. The Lumex registered moderate levels of mercury in the air. BT staff inspected the area and concluded that there is a possible leak from the thermometers in storage, and requested the hospital to properly pack and store the thermometers to lower the mercury level in the storage area.

1. Public Hospital A

Location	Sampling date / time	Average reading	Maximum reading
Dental Clinic	August 12, 2010 9:15 – 9:25 AM	16.2 ng/m^3	17.1 ng/m^3
Main Laboratory	August 12, 2010 9:39 – 9:53 AM	29.8 ng/m^3	31.7 ng/m^3
Pedia Ward	August 12, 2010 10:04 – 10:15 AM	6.6 ng/m^3	15.6 ng/m^3
Pay Ward	August 12, 2010 10:23 – 10:33 AM	32.8 ng/m^3	43.3 ng/m^3
Auditorium	August 12, 2010 10:56 – 11:56 AM	17.4 ng/m^3	21.7 ng/m^3
Storage, cabinet closed	August 12, 2010 1:38 – 1:48 PM	196.2 ng/m^3	206.2 ng/m^3
Storage, cabinet open 1 (sphygmo)	August 12, 2010 1:50 – 2:00 PM	2,442.2 ng/m^3	6,760.9 ng/m^3
Storage, cabinet open 2 (thermometers)	August 12, 2010 2:01 – 2:11 PM	573.8 ng/m^3	2,572.3 ng/m^3
Outdoor storage, closed	August 12, 2010 2:22 – 2:29 PM	12.7 ng/m^3	36.2 ng/m^3
Outdoor storage, open	August 12, 2010 2:30 – 2:40 PM	982.4 ng/m^3	2,152.7 ng/m^3
Equipment repair room 1	August 12, 2010 2:47 – 2:58 PM	111.8 ng/m^3	843.3 ng/m^3
Equipment repair room 2	August 12, 2010 3:00 – 3:10 PM	75.1 ng/m^3	166.7 ng/m^3
Critical care unit 1	August 12, 2010 3:11 – 3:21 PM	27.0 ng/m^3	28.8 ng/m^3
Critical care unit 2	August 12, 2010 3:23 – 3:27 PM	32.1 ng/m^3	39.7 ng/m^3

Location	Sampling date/Time	Average reading	Maximum reading
Dental clinic	December 21, 2010 8:12 Am – 8:20 AM	16.5 ng/m^3	20.0 ng/m^3
Entrance hallway	December 21, 2010 8:30 AM – 8:38 AM	29.9 ng/m^3	274.0 ng/m^3
Biomedical lab	December 21, 2010 8:56 AM – 9:02 AM	113.1 ng/m^3	215.7 ng/m^3
Main laboratory	December 21, 2010 9:10 AM – 9:18 AM	21.6 ng/m^3	32.7 ng/m^3
Outside storage area – closed	December 21, 2010 9:30 AM – 9:38 AM	6.7 ng/m^3	11.1 ng/m^3
Outside storage area – open	December 21, 2010 9:42 AM – 9:50 AM	28.7 ng/m^3	215.0 ng/m^3
Physical plant office	December 21, 2010 9:56 AM – 10:04 AM	103.0 ng/m^3	151.6 ng/m^3
Critical care unit	December 21, 2010 10:12 AM – 10:20 AM	12.7 ng/m^3	46.4 ng/m^3
Auditorium	December 21,2010 10:24 AM – 10:32 AM	6.9 ng/m^3	10.2 ng/m^3
Pay ward	December 21, 2010 10:40 AM – 10:48 AM	5.6 ng/m^3	14.4 ng/m^3
Pediatric ward	December 21, 2010 10:54 AM – 11:02 AM	8.8 ng/m^3	11.3 ng/m^3

2. Public Hospital B

Location	Sampling date/Time	Average reading	Maximum reading
Outside of front gate	January 18, 2011 4:06 PM – 4:14 PM	4.5 ng/m^3	9.6 ng/m^3

E. Dumpsites / Landfills

Wastes contaminated with mercury are another source of mercury pollution in the country. One of the most troubling aspects of wastes contaminated with mercury is that these wastes are often mixed with regular household wastes that either dumped or at time burned. Fluorescent bulbs, thermometers, and other devices or products that contain mercury are prime sources of wastes that are often mixed and dumped.

In this regard, BT visited several dumpsites in Metro Manila. Below are the results of BT's analysis:

1. Pier 18 / Smokey Mountain

Location	Sampling date / time	Average reading	Maximum reading
CRT breaking *Capulongan St.*	January 4, 2011 10:37 – 10:47 AM	15.2 ng/m^3	37.6 ng/m^3
Dump site *Pier 18, Smokey Mt. 2*	January 4, 2011 11:03 – 11:13 AM	3,137.2 ng/m^3	22,633.7 ng/m^3
CFL breaking area	January 4, 2011 11:14 – 11:24 AM	181.2 ng/m^3	1,460.7 ng/m^3
Wire burning *Pier 18 dumpsite*	January 4, 2011 11:25 – 11:35 AM	763.0 ng/m^3	6,535.7 ng/m^3
Residential area *Pier 18*	January 4, 2011 11:47 – 11:57 AM	21.6 ng/m^3	71.4 ng/m^3
Paradise Heights	January 4, 2011 12:01 – 12:11 PM	12.3 ng/m^3	105.8 ng/m^3
Agri-crops plantation *Smokey Mt. 1*	January 4, 2011 12:11 – 12:21 PM	272.4 ng/m^3	4,060.1 ng/m^3

F. Other Areas:

To highlight the presence of mercury vapor throughout the metropolis, BT visited several government agencies, shopping malls, and other areas often visited by the public to check on the levels of mercury. The table below outlines the

Government Offices

Location	Sampling date / time	Average reading	Maximum reading
Quezon City Hall *Main Building*	January 16, 2011 12:19 – 12:29 PM	5.3 ng/m^3	10.4 ng/m^3
DENR Office – outside	December 30, 2010 6:44 PM – 6:52 PM	2.6 ng/m^3	4.0 ng/m^3
Malacañan Palace – outside	January 17, 2011 2:02 PM – 2:10 PM	3.9 ng/m^3	7.9 ng/m^3

Main Thoroughfares

Location	Sampling date / time	Average reading	Maximum reading
Central Avenue, Quezon City	December 30, 2010 10:45 AM – 10:47 AM	3.5 ng/m^3	5.6 ng/m^3
	December 31, 2010 10:28 PM – 10:36 PM	7.2 ng/m^3	9.6 ng/m^3
	December 31, 2010 10:40 PM – 10:46 PM	3.1 ng/m^3	3.6 ng/m^3
Visayas Avenue, Quezon City	December 30, 2010 11:05 AM – 11:15 Am	2.4 ng/m^3	6.8 ng/m^3
	December 30, 2010 2:04 PM – 2:05 PM	1.3 ng/m^3	1.7 ng/m^3
	December 30, 2011 4:28 PM – 4:42 PM	13.9 ng/m^3	32.3 ng/m^3
Roxas Boulevard, Manila	January 17, 2011 4:00 PM – 4:08 PM	0.4 ng/m^3	0.8 ng/m^3
EDSA cor. East Avenue, Quezon City	January 17, 2011 4:45 PM = 5:54 PM	17.0 ng/m^3	19.7 ng/m^3

Community located near a hazardous waste treatment facility

Location	Sampling date / time	Average reading	Maximum reading
Creek behind treatment facility	January 15, 2011 9:28 AM – 9:36 AM	4.6 ng/m^3	18.4 ng/m^3
Brgy. Maguyam perimeter to Cleanway	January 15, 2011 9:44 AM – 9:48 AM	2.7 ng/m^3	8.18 ng/m^3
Cleanway front location	January 15, 2011 10:10 AM – 10:18 AM	13.5 ng/m^3	30.8 ng/m^3
Brgy. Maguyam, side perimeter to Cleanway	January 15, 2011 10:29 AM – 10:37 AM	10.6 ng/m^3	18.6 ng/m^3
Brgy. Maguyam residential area-baseline test	January 15, 2011 10:50 AM – 10:58 AM	9.8 ng/m^3	35.0 ng/m^3
Brgy. Maguyam residential area	January 15, 2011 11:32 AM – 11:40 AM	10.8 ng/m^3	19.3 ng/m^3
Cleanway entrance	January 15, 2011 12:30 PM – 12:38 PM	4.8 ng/m^3	14.3 ng/m^3

Parks and Shopping Malls

Location	Sampling date / time	Average reading	Maximum reading
Quezon Memorial Circle – bike path	January 16, 2011 12:59 – 1:09 PM	4.6 ng/m^3	7.6 ng/m^3
Rizal Park	January 17, 2011 2:52 PM – 3:00 PM	4.9 ng/m^3	12.6 ng/m^3
SM Mall of Asia – Back location	January 17, 2011 3:36 PM – 3:45 PM	-0.2 ng/m^3	0.9 ng/m^3
Rockwell Power Plant Mall	January 18, 2011 5:46 PM – 5:55 PM	4.1 ng/m^3	8.3 ng/m^3
Tagaytay Picnic Grove	January 15, 2011 1:41 PM – 1:49 PM	18.0 ng/m^3	31.8 ng/m^3

Foreign Embassies

Location	Sampling date / time	Average reading	Maximum reading
United States Embassy	January 18, 2011 1:52 PM – 2:00 PM	4.8 ng/m^3	6.3 ng/m^3
Japanese Embassy	January 18, 2011 4:32 PM – 4:41 PM	4.0 ng/m^3	20.2 ng/m^3

Churches

Location	Sampling date / time	Average reading	Maximum reading
Malate Church	January 17, 2011 3:07 PM – 3:16 PM	0.7 ng/m^3	2.4 ng/m^3

Others

Location	Sampling date / time	Average reading	Maximum reading
Manila Yacht Club	January 17, 2011 4:22 PM – 4:30 PM	-0.8 ng/m^3	1.2 ng/m^3
Manila Hotel	January 17, 2011 2:28 PM – 2:36 PM	-0.2 ng/m^3	1.3 ng/m^3
Cultural Center of the Philippines	January 17, 2011 3:18 PM – 3:27 PM	0.6 ng/m^3	1.3 ng/m^3

New Year Celebrations

Location	Sampling date / time	Average reading	Maximum reading
Firecracker shop, Visayas Avenue	December 30, 2010 5:30 PM – 5:42 PM	2.2 ng/m^3	26.0 ng/m^3
Quezon Memorial Circle fireworks display	December 30, 2010 10:22 PM – 10:30 PM	18.3 ng/m^3	23.9 ng/m^3
Brgy. Central – media noche celebration	December 31, 2010 11:34 PM – 11:42 PM	2.6 ng/m^3	3.1 ng/m^3
Brgy. Central – New Year's day	January 1, 2011 12:14 AM – 12:22 AM	2.2 ng/m^3	3.0 ng/m^3

8. Standard Reference Levels

As early as 1991, the World Health Organization has already recognized the harmful effects of mercury to human health, saying that there is no established "safe level" for mercury exposure, below which no adverse effects occur. However, because of the presence and persistence of mercury in environmental media, concerned agencies in the United States have established standard reference levels for mercury exposure.

US Environmental Protection Agency (EPA) – for homes

Action level 1:	Immediate evacuation	10,000 ng/m^3
Action level 2:	Schedule relocation ASAP	Between 1,000 and 10,000 ng/m^3
Action level 3:	Safe re-occupancy	Below 1,000 ng/m^3

US Department of Health and Human Services - Agency for Toxic Substances and Disease Registry (ATSDR)

Home evacuation level: 10,000 ng/m^3

US Department of Labor – Occupational Safety and Health Administration (OSHA) Maximum permissible exposure limit:

100,000 ng/m^3 (level for workplace settings, 8-hour workday)

Locally, the Clean Air Act also created a maximum permissible limit of **5 milligrams per Newton centimeter (mg/Ncm)** of elemental mercury at the point of emission, with respect to any trade, industry, process and fuel-burning equipment or industrial plant emitting air pollutants.

9.Say…aaaHg! Campaign

Aside from the mercury vapor tests done in the specific sites listed in Section VIII, BT also used the Lumex RA-915+ to organize the *Say…aaaHg!* campaign in the Philippines. *Say…aaaHg* was initiated by the European Environmental Bureau through Zero Mercury Working Group and launched at 1st International Negotiation Committee meeting for the development of legally binding instrument on mercury in Stockholm, Sweden in June 2010, to raise awareness on the various sources of human exposure to mercury, particularly mercury vapor leaking from dental amalgams.

Since BT conducted the Say…aaaHg campaign, at least 300 individuals lined up to participate in the activity. Each participant was given a piece of chewing gum and allowed to chew for around 30 seconds, concentrating on the tooth or teeth that contained dental fillings. After chewing, the participant's breath was tested using the Lumex RA-915+. They were given info cards containing their breath test result and information on mercury.

Although the range of mercury concentrations in the breath tests was far from the standard maximum reference levels provided by various agencies, many participants expressed concern over finding mercury leaking from their dental fillings.

By educating the participants and answering their questions, the *Say…AaaHg!* activity was able to raise interest and awareness about mercury through hands-on participation and practical advice. The participants were advised to be conscious of other sources of mercury exposure due to the existing mercury source in their dental fillings, and to be aware of the possible triggers of mercury amalgam volatilization – hot or acidic food and drinks, friction from chewing, and bad dental practices, among others.

In the wake of the ban on 11 mercury-tainted cosmetics issued by the Food and Drug Administration last February 2010, Ban Toxics conducted a mercury vapor test on several brands of banned whitening creams, including Jiao Li, Xin Jiali, and M Cream. Elemental mercury vapor was found to escape even from the closed containers, at an average of 2 ng/m^3. Once opened, the reading shot up to as high as 11,000 ng/m^3.

Mercury is reportedly used in cosmetics for its skin-bleaching and anti-microbial properties. Despite the ban, the mercury-tainted products continue to be smuggled into the country and sold for public consumption. All of the banned products were imported from China.

10. Laws on Mercury

A. Toxic Substances, Hazardous and Nuclear Wastes Control Act (Republic Act 6969)

Republic Act 6969, also known as the Toxic Substances, Hazardous and Nuclear Wastes Control Act of 1990 provides the legal framework for mercury in the Philippines. The law deals with the regulation, restriction or prohibition of the importation, manufacture, processing, sale, distribution, use and disposal of chemical substances and mixtures that present unreasonable risk and/or injury to health and the environment. DENR Administrative Order 1992-29, the statute's Implementing Rules and Regulations (IRR), include mercury and mercuric compounds (D407) in the table of prescribed hazardous waste. Republic Act 6969 and its IRR prescribe a general regulatory framework as procedures and requirements for hazardous waste management in the Philippines, prohibit the entry, transit and disposal of hazardous wastes into the Philippine territory and encourage proper management of hazardous wastes through minimization, recycling, treatment and landfilling of hazardous waste.

To further control the use and dispersion of mercury and mercury compounds into the environment, the DENR issued Administrative Order No. 97-38 or the Chemical Control Order (CCO) for mercury and mercury compounds. The order provides for additional requirements and procedures in the importation, manufacture, distribution and use of mercury and mercury compounds. It also lays down certain conditions in the treatment, transport, storage and disposal of mercury-bearing or mercury-contaminated wastes in the Philippines.

B. Clean Air Act of 1998 (Republic Act 8749)

Republic Act 8749 provides for a comprehensive air pollution program which includes the implementation of air quality standards. Under the law and its IRR, incineration, or the burning of municipal, biomedical and hazardous wastes, a process which emits poisonous and toxic fumes, is prohibited. The Act likewise mandates the DENR to promote the use of state-of-the-art, environmentally-sound, and safe non-burn technologies for the handling, treatment, thermal destruction, utilization, and disposal of sorted, unrecycled, uncomposed municipal, bio-medical and hazardous wastes.

C. Pollution Control Law of 1976 (Presidential Decree 984

Presidential Decree 984 prohibits the disposal into the water, air and/or land resources of the Philippines of any liquid, gaseous or solid wastes that will tend to alter their physical, chemical and biological properties or is likely to create or to render such water, air and land resources harmful, detrimental or injurious to public health, safety or welfare or which will adversely affect their utilization for domestic, commercial, industrial, agricultural, recreational or other legitimate purposes.

D. Department of Health Administrative Order No. 21, s. 2008

DOH AO No. 21 is known as the gradual phase-out of mercury and mercury-containing equipment from all health care

facilities in the country—hospitals, infirmaries, birthing homes, and all types of clinics. It ordered health care facilities to immediately discontinue distribution of mercury thermometers in patient kits, to follow a gradual phase-out plan leading to full implementation by 2010, and to conduct inventory of all mercury-containing devices in their facilities.

E. Department of Education Memorandum No. 160, s. 2010

DepEd Memorandum No. 160 reiterates DOH AO No. 21 with a special focus on schools. It also calls for a review of existing department regulations on safety in science laboratories, to ensure that mercury is excluded from the list of commonly used chemicals.

11. Relevant Findings and Recommendations

Within the six-month research period, BT was able to visit and monitor many varied sites in the Philippines. Following are several relevant findings based on our results and experiences:

1. A background level of mercury already exists in the Philippines. Mercury vapor was detected in small concentrations even in areas with no known or alleged mercury use.

2. The highest mercury vapor concentrations were found in sites where mercury was actually being used or stored. These sites include mining communities, dumpsites where mercury-containing products were burned or dumped, and storage areas containing broken or leaking mercury equipment.

3. Mercury pollution can travel distances beyond the immediate vicinity of the source.

4. In mining areas, mercury concentrations increased dramatically during operations when mercury is used. Higher than background level mercury can be detected even when operations have finished, but readings are greatly higher when the equipment and processes involving mercury are employed.

5. Existing government air monitoring does not include heavy metals such as mercury. There is no monitoring of mercury emissions in hotspots such as small-scale mining areas and the nearby environs.

6. Despite the Department of Health's Administrative Order No. 21 and the Department of Education's Memorandum No. 160, many schools and school clinics still contain mercury and mercury-containing devices. The mercury and related equipment are either being used actively, or improperly stored. These facts shows that the DOH and DepEd need to ensure that their respective regulations are being implemented.

7. Consumers of mercury and mercury-containing products are often unaware that the product they are purchasing contains mercury. There is still a considerable lack of awareness on the issue as well as lack of information on products, such as labels and warnings, informing consumers of the presence of mercury.

8. Mercury-containing wastes (e.g., discarded mercury-containing lamps, broken mercurial thermometers, etc.) are often disposed or mixed with regular trash. There is currently no functional national system for the environmentally sound management for mercury-containing wastes.

9. For mercury in storage, proper and careful packing of the mercury containing equipment and correct storage makes a big difference in reducing the amount of mercury being released into the air. Even temporary, makeshift storage solutions were proven to reduce the mercury emission dramatically. For instance, elemental mercury that is contained in a plastic jar that is covered tightly and taped, still is able to leak from the container. Better packaging utilizing zip-top bags, with very little expense, can greatly reduce mercury leak.

10. There is no national or provincial site for the storage of mercury that is

removed from commerce or voluntarily surrendered to the government. The government, institutions and individuals do not have an option on the proper management of mercury, either as waste or commodity.

Several recommendations and actions points must be taken:

1. Reducing or eliminating man-made mercury sources. The Lumex mercury vapor spectrometer detected mercury when there was mercury present in the air. Despite the diverse results, which even shifted within a specific sector at times, one major conclusion can be drawn: mercury exists in the air we breathe, however small the amount may be.

   Recognizing that there are many possible sources of mercury vapor, reducing and move towards eliminating man-made sources of mercury is the most pragmatic solution to eliminating increased mercury exposure by individuals and communities.

2. Enforcement of regulations. The government needs to step up and ensure all applicable laws, from the Clean Air Act to RA 6969 and applicable regulations are observed and implemented by all. Consistent enforcement of these crucial regulatory measures can immediately result in a marked decrease in man-made emissions of mercury.

3. Information and awareness-raising. It was also evident from the investigation that more information on mercury and awareness-raising was needed. There was an initial reluctance by some schools to allow BT to check for mercury levels in their laboratories, not because of a concern that BT will find high levels of mercury, but because the schools have stopped using mercury and have placed the elemental mercury in storage. Only when BT showed the schools that mercury was leaking from the closed container through the Lumex that the school administrators obtained clearer information on the dangerous characteristic of mercury.

   The same can also be said when BT conducted tests on mercury laced-skin whitening creams which exhibited mercury leaks even when closed.

4. Crucial to the above recommendation is the proper labeling of products and equipment that contain mercury, especially if there are no mercury-free alternatives that are available. Unless consumers and users are aware of the presence of mercury in the products it will be very difficult to take corrective action against it.

   More information and greater public awareness on the dangers of mercury is still needed to properly push communities into action against mercury pollution.

5. Consistent and regular monitoring. The government and private sector should invest in the necessary equipment and personnel training for consistent monitoring of mercury in the air, especially in mercury hotspots. The entities which currently possess the appropriate equipment should make their services available for public interest. As of this writing, all four Lumex-holding institutions in the country charge rental and service fees for the use of their machines.

   Although BT was limited by time and financial constraints, there are still many areas which will benefit greatly from similar monitoring. If free or low-cost use of the equipment is not possible, then the relevant

institutions are enjoined to make full use of their machines by conducting monitoring projects in various sectors and make the data available to the public.

6. Proper packaging and storage of mercury. The sectors and institutions that store or actively use mercury are encouraged to use the observations from this research in properly packing and storing mercury. While the ultimate goal is a complete ban on mercury use, and a central, government-controlled mercury storage facility, interim measures are needed to minimize unnecessary exposure and any untoward mercury spills.

   For example, for schools and hospitals which need to store mercury temporarily, it will help to note that mercury emissions are reduced to nearly zero when mercury and the related devices are stored in a tightly covered durable plastic container, and double-bagged in heavy-duty zip-lock plastic bags. For more information visit: *www.basel.int/techmatters/**mercury**/guidelines/2010-12-01.doc* and http://content.undp.org/go/cms-service/download/publication/?version=live&id=2681158 containing guidelines in the proper packing and storing of mercury containing equipment or devices and wastes.

   For small-scale mining communities, it was proven that mercury concentration is very high when whole-ore mercury amalgamation and panning processes are employed. Thus, they should be advised to stop this process and move to mercury-free techniques and processes.

7. Put in place a functional system and procedure, from the barangay level all the way to the national level, for the environmentally-sound collection, management, and storage of mercury, products containing mercury, and mercury-containing wastes.

8. Increase attention on air pollution caused by heavy metals such as mercury. As observed earlier, much of the focus on the monitoring and mitigation of air pollution is on familiar pollutants such as carbon dioxide, volatile organic compounds and the like. As the results from this investigation confirm, a background level of mercury contamination already exists in the Philippines. Thus, the relevant government agencies and law-enforcing bodies must take quick action to increase awareness on heavy metal air pollution, and strengthen the enforcement of the pertinent laws.

   For instance, the Clean Air Act mandates that an inventory of pollutant emissions must be taken from all stationary, mobile and area sources once every three years.[14] It is recommended that the monitoring of mercury vapor be included in this inventory, and that special attention be given to heavy emitters such as the mining and coal power industries.

9. International action on eliminating man-made sources of mercury. The Philippines needs to continue engaging the international process that will control all man-made sources of mercury, and raise Filipino interest on the issue. Even if the Philippines is able to control mercury sources from within its boundaries, products that contain mercury, mercury pollution from neighboring countries can still undermine local efforts to address the problem. Thus, it is important for the Philippines to fight for a global treaty that comprehensively and adequately

addresses global man-made mercury pollution sources.

The figures presented in this investigation seem to be insignificant and minuscule. After all, what is 1 ng/m^3 in the greater scheme of things? It is much less than a drop in the bucket. However, we echo the outlook of the World Health Organization, when it announced as early as 1991 that there are no established safe levels for mercury exposure, under which no adverse effects are observed.[15] The only way to find out if one will be sensitive enough to be affected by mercury is to exhibit the symptoms of mercury poisoning, and by then, the irreversible damage will have been done.

As the background level continues to build up quietly and unnoticed, without adequate monitoring from any of the relevant agencies and steps to eliminate these sources, we may someday find ourselves living in an environmental crisis, when even simply breathing is enough to jeopardize our health and productivity. The right to clean air and a healthy environment is a human right that all are entitled to. The present generation has the burden of knowledge and responsibility to ensure that the mercury cycle ends, not just for our sake in the present, but for the many generations of Filipinos to come.

- END -

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