Terminal Storage Options of Mercury Wastes in the Philippines

by

Ban Toxics!
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Executive Summary

Mercury is one of the most dangerous environmental pollutants, both in its elemental form and in chemical combinations. It is a known neurotoxin and attacks the nervous system. When released into the environment mercury is transformed to its most pernicious form, methylmercury, which bioconcentrates and bioaccumulates in fish and enters the human body when eaten. In the human population the fetus, young children, and pregnant women are most sensitive to the adverse impacts of mercury.

The United Nations Environment Programme has determined that global mercury emissions and releases need to be significantly reduced in order to reduce health and environmental impacts. Armed with this knowledge countries have begun to take action by setting up standards for maximum content of mercury in food or by restrictions on the use of mercury.

Mercury Sources in the Philippines

In 2008 the Philippine Department of Environment and Natural Resources conducted an inventory of mercury sources and releases in the Philippines. The inventory revealed that one major source of mercury emissions, 20% of total, in the Philippines come in the form of wastes from products and processes, e.g. discarded thermometers, batteries, and other mercury-containing devices.

The finding raises additional problems for the Philippines, as it continues to grapple with improper waste disposal. Consider that for municipal wastes generated in Metro Manila alone, approximately 5,250 metric tons of waste generated daily are collected, the remaining 27% of the daily waste or about 1,417.5 metric tons are dumped illegally on private land, in rivers, creeks, Manila Bay, or openly burned. Although there are laws requiring waste segregation at source, very little segregation happens on the ground.

Assuming that the Philippines is able to sequester the mercury contaminated waste; it then faces the prospect of how to manage the mercury so that it does not cycle back into the environment. The study looks into terminal storage the emerging practice in this field by placing the captured mercury in a secure and stable facility for perpetuity.

Terminal Storage Options

There are various terminal storage options existing around the world, and these options can be viewed in two broad categories: above ground and below ground. Each broad category has illustrative models, which the study examined: above ground storage – United States Defense National Stockpile Center (DNSC); below ground storage – Germany, landfilling in disused salt mines; below ground storage - Sweden, deep rock injection.

All three options present high technical and financial costs. Site location, geographical stability, hydrology, occurrence of natural disasters, such as hurricanes, are just some of the factors that influenced how these facilities were chosen. Equally, the financial costs are steep for the most part. For deep rock injection, Sweden is expected to incur SEK 200 – 300 million (approximately US$ 25 to 37 million) for 1,000 – 20,000 tonnes of high-level mercury waste and the DNSC shelled out US$ 17,450,000 for start-up costs of their facility and is expected to incur at least US$ 547,904 of recurring costs per year to manage 4,436 tons of commodity grade elemental mercury. What appears to be the least expensive is the German salt mines, where the company running the facility is charging €270 / tonnes of mercury waste.

Gaps in Policy and Law

At the fundamental level, the study examined existing Philippine laws and policy on mercury whether these are robust enough to support an ambitious project such a terminal storage. The study concluded that at present a comprehensive national policy on mercury that includes and recognizes terminal storage as a key facet in addressing the mercury problem is lacking in the Philippines. Moreover, existing laws though possessing a range of measures for the establishment of disposal facilities are inadequate in the area of terminal storage. The study found inconsistencies in waste management priorities set by law with respect to mercury wastes, inappropriate exemptions, and weakness in the liability regime.

Recommendations

Mercury poses a multi-faceted challenge to many nations, more so to a developing country such as the Philippines. The idea of sequestering the releases of this toxin and storing it permanently is simply revolutionary and demands a multi-faceted and full life-cycle approach. In order to this, the Philippine government needs to abandon certain biases on regulation and view terminal storage, its implications and demands, as a facet of a comprehensive approach and not an end in and of itself.

The study sees the following gaps that need to be addressed:

A. Creation of a comprehensive national policy on mercury with a provision for terminal storage with the following elements:

1. Terminal Storage as Part of Waste Management Policy
2. Controlling the supply of mercury
3. Controlling the demand of mercury
4. Trade Restrictions on Mercury-Containing Products and Technologies/Processes Promoting Mercury
5. Fiscal Incentives to Hg-Free Industries/Products
6. Promotion of Alternatives/Substitution
7. Multi-Stakeholder Process
8. Provide current and relevant information on mercury; Ensure access to such information; and proper risk communication

B. Creation of a cohesive legal infrastructure to support the national policy on mercury, addressing the following areas:

1. Comprehensive measures needed to address the intentional anthropogenic sources of mercury in the Philippines
2. Designate terminal storage as an environmentally sound solution for mercury wastes
3. Modify existing exemptions on end-users of mercury

4. Full prohibition on the discharge of mercury-containing wastes into the environment
5. Expanding the responsibility of generators/distributors of wastes into an extended-producer responsibility model
6. Clarify roles and jurisdictions of the Departments involved in the national policy on mercury

C. Creation of a multi-stakeholder process to review options and recommend an option
D. Factor in social and political in criteria for establishing a terminal storage facility.

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1. BACKGROUND

1.1 Project Objectives

The concept of terminal storage is not well understood. In this regard the objectives of the study are as follows:

A. Provide Philippine decision makers information and insight on the environmentally sound options for the terminal storage of mercury waste ensuring permanent retirement of mercury from use and commerce.
B. Empower Philippine communities by providing them information to aid in understanding the consequences of improper mercury waste disposal and the need for environmentally sound management of mercury waste.
C. Give insight at the regional/international level of the challenges faced by a developing country, such as the Philippines, in the disposal of mercury waste.

1.2 Context

Reducing the global supply of mercury is one of the best ways to address the severity of the mercury crisis (i.e. contamination/exposure) the world is facing. A critical component of this approach, which is presently seen as a priority, is the storage of excess mercury. The rationale is that once mercury is captured, it must not to be re-circulated or resold in the global marketplace which increases the probability of its eventual release.

The importance and urgency of terminal storage has been reflected in several United Nations Environment Programme Governing Council (GC) Decisions:

- Decision 23/9, adopted by the twenty-third session of the on 25 February 2005, requested Governments to "consider curbing primary production and the introduction into commerce of excess mercury supply".

- Decision 24/3 adopted by the twenty-fourth session of the GC/Global Ministerial Environment Forum on 9 February 2007, the GC established mercury supply reduction as a global priority, and urged governments “to gather information on the options and solutions for the long-term storage of mercury".

- Decision 25/5, last 16 February 2009 calls for moving forward with an elaboration of a legally binding instrument on mercury, and directing the Executive Director of UNEP to convene an international negotiating committee (INC) by 2010. Part of the INC mandate is to develop a comprehensive and suitable approach to mercury including provisions on the reduction of supply and the enhancement of environmentally sound storage.

1.3 Scope

Mercury has various sources. The focus of this study will be on mercury wastes from products that are discarded into the waste stream. The study does not focus on the mercury releases from coal-fire power plants nor from small-scale artisanal gold mining.
Further, the study's scope is limited to reviewing terminal storage options and does not address means or methods of collecting and transporting mercury wastes to a terminal storage facility.

2. MERCURY

2.1 A New Approach

Since ancient times, man has been aware of the toxic nature of elemental mercury (Hg). In fact, Hg poisoning's most enduring image is that of the Mad Hatter, a fictional character under the famous children's story, Alice's Adventures in Wonderland by Lewis Carroll. The character's name was undoubtedly inspired by the phrase "as mad as a hatter," describing the eventual condition which workers curing felt hats suffer from after much usage and inhalation of mercuric nitrite.

Until a few decades ago the health concern on Hg was focused on occupational exposure, e.g. in mines, even though there were several documented incidents of local Hg poisoning within the past 50 years and evidence of wildlife mortality in the 1960s, notably that Hg poisoning incident that happened in Minamata, Japan.

In February 2001, the 21st Governing Council of the United Nation's Environment Programme (UNEP) decided to undertake a global assessment of mercury and mercury compounds with other stakeholders, the results of which were to be submitted in 2003 for the 22nd Governing Council meeting of UNEP. The evidence that was gathered in this process has caused a sea-change in how mercury pollution is viewed and has in fact ushered an immediate and more coordinated global response.

The information presented below is

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 1950s 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.

In all, 900 people died and 2,265 people were certified as having directly suffered from mercury poisoning - now known as Minamata disease.

culled mainly from the information submitted to UNEP forming part of the 2002 Global Mercury Assessment.

2.1 Properties and Uses of Mercury

Mercury can exist in three oxidation states: in pure form, Hg^0 (metallic), monovalent or Hg^{1+} (mercurous) and divalent or Hg^{2+} (mercuric). The properties and behavior of mercury depend on the oxidation state. Most of the mercury in water, soil, sediments, or biota (i.e., all environmental media except the atmosphere) is in the form of inorganic mercury salts and organic forms of mercury.

Mercury is widely used because of its unique properties. In its elemental form, it is silver-white metal and is liquid at room temperature, and it expands and contracts very precisely in response to temperature changes. Thus, mercury has been traditionally used in thermometers. Mercury is also very volatile, at room temperature it will evaporate and form mercury vapors and the higher the temperature the faster rate of evaporation. These vapors are odorless and colorless.

Mercury is very dense, and it maintains its volume in response to atmospheric pressures, making it an ideal material for devices designed to measure pressure. As a metal, mercury conducts electricity very well, making it a suitable material for some electrical switches. Mercury forms alloys with almost all other metals, such as gold. This process called amalgamation has made mercury-use in gold-mining, particularly in small-scale and artisanal mining prevalent.

Mercury plays an important role as a process or product ingredient in several industrial sectors. In the electrical industry, mercury is used in components such as fluorescent lamps (including CFLs), wiring devices and switches (e.g., thermostats) and mercuric oxide batteries. Mercury is also used in navigational devices, the health care sector, in instruments that measure temperature and pressure and other related applications. It is also a component of dental amalgams used in repairing dental caries (cavities).

In addition to specific products, mercury is used in numerous industrial processes. The largest quantity of mercury used in manufacturing internationally is the production of chlorine and caustic soda by mercury cell chlor-alkali plants. Apart from amalgamation mentioned earlier, other processes utilizing mercury include: use in nuclear reactors, wood processing (as an anti-fungal agent), as a solvent for reactive and precious metals, and as a catalyst. Mercury compounds are also frequently added as a preservative to many pharmaceutical products.

2.2 Mercury in the Environment

Mercury is an element. The earth contains the same amount of mercury since the planet was formed. As an element, mercury has been present in the environment from natural sources, such as, volcanic eruptions and forest fires. And like other elements, mercury cannot be created or destroyed through chemical processes.

Mercury, however, can cycle in the environment as part of both natural and anthropogenic (man-made) activities and therefore while the total amount on the planet remains constant, certain portions of planetary space can acquire enhanced amounts of mercury. Measured data and modeling results indicate that human activities have substantially contributed to the amount of mercury mobilized and released into the environment and in the food chain.[1]

Mercury has been used in a wide range of products and industrial processes, and most of these anthropogenic uses are presently in:

- Industrial processes that produce chlorine (mercury chlor-alkali plants) and/or vinyl chloride monomer (for polyvinyl chloride (PVC) production, and polyurethane elastomers);
- Artisanal and small-scale gold mining;
- Products, electrical switches, thermostats, measuring and control devices, fluorescent light bulbs (e.g. CFLs), batteries, and dental amalgam;
- Laboratories, cosmetics, pharmaceuticals, paints, and jewelry.

In addition to these releases, some industrial processes contribute to what is called unintentional releases, such as coal-fired power generation, cement production, mining and other metallurgic activities.

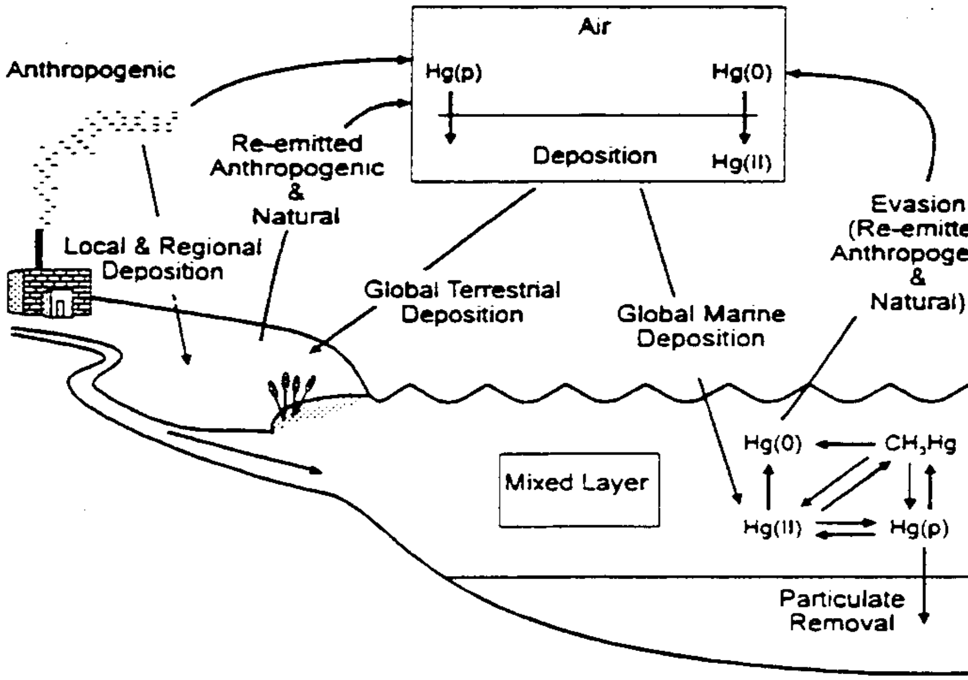
Coal-fired power production is deemed the single largest global source of atmospheric mercury emissions. It is also acknowledged that wastes from products and industrial processes containing mercury can be a significant source of mercury to the environment as well.

2.2.1 The Role of Atmospheric Releases and Processes

Once in the atmosphere, mercury is widely disseminated and can circulate for years, accounting for its wide-spread distribution. Atmospheric mercury can be widely dispersed and transported thousands of kilometers from likely emission sources. The distance of this transport and eventual deposition depends on the chemical and physical form of the mercury emitted.

A basic diagram of the global mercury cycle is presented in Figure 1 below. As indicated, mercury is emitted to the atmosphere by a variety of sources, dispersed and transported in the air, deposited to the earth, and stored in or transferred between the land, water, and air.

Figure 1
The Global Mercury Cycle



Cited from EPA Mercury Study Report to Congress. Volume III: Fate and Transport of Mercury in the Environment, December 1997.

2.3 Mercury Toxicology

Mercury and mercury-containing compounds are highly toxic and have a variety of significant adverse effects on human health, wildlife and the environment.

2.3.1 Impacts on Plant and Wildlife

Concentrations of mercury in the tissues of wildlife species have been reported at levels associated with adverse effects.

On fish adverse effects include death, reduced reproductive success, impaired growth and development and behavioral abnormalities. Effects of mercury on birds and mammals include death, reduced reproductive success, impaired growth and development and behavioral abnormalities. Sub-lethal effects of mercury on birds and mammals include liver damage, kidney damage, and neurobehavioral effects. Effects of mercury on plants include death, plant senescence, growth inhibition and decreased chlorophyll content, leaf injury, root damage, and inhibited root growth and function.

2.3.2 Impacts on Humans

There are several factors which can determine whether humans will suffer adverse effects from mercury and the severity of the effects. These are: the chemical form of mercury; the dose or amount of exposure; the age or developmental stage of the person exposed (i.e. the fetus is the most sensitive and susceptible to ill-effects of mercury); the route of exposure – inhalation, ingestion, or dermal contact.

Elemental mercury primarily causes health effects when it is breathed as a vapor where it can be absorbed into the bloodstream directly through the lungs. Exposure can give rise to the following symptoms: tremors; emotional changes (e.g., mood swings, irritability, nervousness, excessive shyness); insomnia; neuromuscular changes (such as weakness, muscle atrophy, twitching); headaches; disturbances in sensations; changes in nerve responses; performance deficits on tests of cognitive function. At higher exposures there may be kidney effects, respiratory failure and death.

High exposures to inorganic mercury may result in damage to the gastrointestinal tract, the nervous system, and the kidneys. Symptoms of high exposures to inorganic mercury include: skin rashes and dermatitis; mood swings; memory loss; mental disturbances; and muscle weakness. Both inorganic and organic mercury compounds are absorbed through the gastrointestinal tract and affect other systems via this route. However, organic mercury compounds are more readily absorbed via ingestion than inorganic mercury compounds.

Of the different forms of organic mercury, methylated mercury is the most toxic and it bioaccumulates in organisms and biomagnifies up the food chain. Its effect on humans is that of a potent neurotoxin causing a wide array of neurological disorders and can easily be fatal at higher concentrations.

2.3.2.1 At Risk Populations

All humans are exposed to some form of low level of mercury. In particular, individuals and communities who are directly exposed to mercury through their occupation or local industry may be at risk. However, certain populations are more sensitive or susceptible to the adverse effects of mercury than others. Of particular concern are:

- The fetus, the newborn and young children. They are especially sensitive to mercury exposure because of the sensitivity of the developing nervous system. New mothers, pregnant women, and women who might become pregnant are often included in this category, in utero exposure to mercury could occur if the mother is exposed as well. Also, newborns could be exposed to mercury through breast milk.
- Individuals with diseases of the liver, kidneys, nerves, and lungs are at higher risk from suffering the toxic effects of mercury.
- Other sub-populations may be at greater risk because they are exposed to higher levels of methyl mercury such as subsistence fishers, and cultures that tend to regularly eat fish and other seafood.

2.4 Mercury Methylation and Bioaccumulation, Exposure Pathways

The methylation of mercury is a key step in the entrance of mercury into food chains. The bio-transformation of inorganic mercury forms to methylated organic forms in water bodies can occur in sediments and the water columns. Not all mercury compounds entering an aquatic ecosystem, however, are methylated.

It has been found that, very often, almost 100% of the mercury that bioaccumulates in fish tissue is methylated. Generally, mercury tends to accumulate up in aquatic food chains so that organisms at higher trophic levels have higher mercury concentrations (biomagnification). Thus, most individuals are exposed to mercury through diet, especially from consumption of fish and other marine species contaminated with mercury.

Mercury accumulates in an organism when the rate of uptake exceeds the rate of elimination. Elimination of methylmercury takes place very slowly resulting in tissue half-lives (i.e., the time in which half of the mercury in the tissue is eliminated) that range from months to years, depending on the nature of the organism (bioaccumulation).

2.4.1 Methylmercury – Human Exposure Pathways

Humans are most likely to be exposed to methylmercury through fish consumption. Exposure may occur through other pathways as well (e.g., the ingestion of methylmercury-contaminated drinking water and food sources other than fish, and uptake from soil and water through the skin). *However, for humans and other animals that eat fish, methylmercury uptake through fish consumption dominates these other routes.*

When methylmercury is ingested it is rapidly and extensively absorbed through the gastrointestinal tract. Methylmercury is distributed throughout the body and easily penetrates the blood-brain and placental barriers in humans and animals. This form of mercury has a relatively long biological half-life in humans; estimates range from 44 to 80 days. Excretion occurs via the feces, breast milk, and urine.

2.4.2 Methylmercury - Human Health Effects

Methyl mercury-induced neurotoxicity is the effect of greatest concern when exposure occurs to the developing fetus, for methyl mercury easily penetrates the placental as well as the blood-brain barrier. In a study of about 900 Faroese children who have been exposed to methyl mercury pre-natally, the researchers noted the children exhibiting neurophysical deficits at 7 years of age. The brain functions most vulnerable seem to be attention span, memory, and language.

It has also been shown that even at low concentrations there appears to be subtle, persistent effects on the children's mental development as observed at about the start of the school age.

Aside from these impacts, methyl mercury once it enters into humans can cause nervous disorders, cancer, brain damage, difficulty in vision, hearing, walking, tremors, coma and even death.

3. Mercury Sources

3.1 In the Philippines

The releases of mercury to the biosphere can be grouped in four categories:

a) Natural sources - releases due to natural mobilisation of naturally occurring mercury from the Earth's crust, such as volcanic activity and weathering of rocks;
b) Current anthropogenic (associated with human activity) releases from the mobilisation of mercury impurities in raw materials such as fossil fuels – mainly coal, and to a lesser extent gas and oil. The release of mercury through the burning of coal in coal-fired power production is deemed the single largest global source of atmospheric mercury emissions;[2]
c) Current anthropogenic releases resulting from mercury used intentionally in products and processes, due to releases during manufacturing, disposal or incineration of spent products or other releases. Mercury in thermometers, batteries, and other products that have become waste and discarded into the waste stream or segregated, are examples of these sources;
d) Re-mobilisation of historic anthropogenic mercury releases previously deposited in soils, sediments, water bodies, landfills and waste/tailings piles.

Of the four categories, (a) releases due to natural mobilisation of mercury and (d) re-mobilisation of anthropogenic mercury previously deposited in soils, sediments and water bodies, are not well understood and largely beyond human control hence there are no immediate solutions for their reductions.[3]

The section looks into the anthropogenic sources of mercury in the Philippines.

Under Philippine law the Department of Environment and Natural Resources (DENR) is mandated to have a database or records of all the importer, manufacturer, distributor and purchaser, and monitor all the end-use category of mercury or mercury-containing products, quantity of products supplied, and the quantity of wastes produced as a result of manufacturing and industrial use.[4]

The required chemicals database which the DENR is tasked to implement has not been fully realized to date,[5] which makes the task of understanding and formulating controls on mercury more difficult.

In early 2008, with the support of the United Nations Environment Programme (UNEP), a Philippine inventory of mercury and mercury compounds was undertaken as part of the UNEP mercury inventory assessment.

The Philippine assessment was a multi-stakeholder effort: government, the private sector, non-governmental organizations, and the academe were part in developing or contributing to the assessment. Consultations were held, as well as distributing surveys to the participants. The process also used secondary data and reputable sources to form an estimation of mercury emissions.

The inventory looked at mercury consumptions and emissions. Due to data limitations as well as drawbacks in the UNEP toolkit, as identified by the study author, the assessment does not provide an exact inventory of total mercury consumption, use, disposal, or emissions which the unrealized chemicals database should be providing.

What the assessment clearly provides, although not definitive, is a preliminary picture of the major categories of mercury sources and emissions in the country, see table below.

Table 1. Summary of Mercury Emissions in the Philippines[6]

Main Source Category	Emissions or Hg output, kg Hg/year						
	Air	Water	Land	Impurity in products	General waste	Sector specific treatment disposal	Total
Extraction and use of fuels/energy sources	31,886	0	0	0	53.90	0	31,940
Primary (virgin) metal production	39,507	13,171	13,197	2,610	0	2,610	71,095
Production of other minerals and materials with mercury impurities	241	0	0	241	0	0	482
Intentional use of mercury in industrial processes	105	11	200	53	0	158	527
Consumer products with intentional use of mercury	943	20	1,120	0	1,082	0	3,165
Other intentional product/process use	7,064	1,331	1,326	266	17,179	532	27,698
Production of recycled metals (secondary) metal production)	0	0	0	0	0	0	0
Waste incineration	0	0	0	0	0	0	0
Waste deposition/landfilling and waste water treatment	48	1,1612	595	0	0	0	1,804
Crematoria and cemeteries	38	0	344	0	0	0	382
TOTAL	78,628	15,694	16,782	3,170	18,314	3,300	137,093

Source: DENR, Mercury Assessment for the Philippines: Using UNEP Inventory Toolkit, September 2008.

Immediately evident from the data above is the category on Primary Virgin Metal Production, which largely involves small-scale gold mining, Extraction and Use of Fuel for Energy resources, referring primarily to coal-fired power generation, and Other Intentional Product/Process Use, which covers an array of industry, such as cement, lime, and pulp and paper production, and interestingly enough products, thermometers, other measuring devices, switches, etc.

Table 1 could be summarized into three main categories with their percentage of release as follows:

Table 2: Major Category of Mercury Emissions in the Philippines

Sub-categories	Total output	Percent of releases
1. Primary Virgin Metal Production	74,769 kg Hg/year	32
2. Extraction and Use of Fuel and Energy Resources	47,862 kg Hg/year	20
3. Other intentional use-thermometer etc	46,653 kg Hg/year	20

Source: DENR, Mercury Assessment for the Philippines: Using UNEP Inventory Toolkit, September 2008.

What jumps out with the broad categories in Table 2, is that it is logical to look at products and waste in the same category. Wastes are products before they were discarded. Thus, for the purposes of managing wastes, it makes sense to include products with wastes when considering emission sources of mercury. Note, the 38% emissions that is not included in Table 2, can be attributed to the other sub-categories.

A sampling of the amount of mercury-containing wastes can be found on the DENR inventory. For instance there is:

Table 3. Estimated Lamp Waste of Establishments Based on Study Survey

Business Type	Flourescent Lamps (pieces/year)
Micro	4,901,412
Small	1,929,240
Medium	1,357,240
Large	2,857,520
Total	**11,045,412**

Source: DENR, Mercury Assessment for the Philippines: Using UNEP Inventory Toolkit, September 2008.

The emission pathways fro other intentional products/process use was also quantified as Table 4 illustrates:

Table 4. Emission Pathways

Other intentional product/ process use	Calc Hg input kg Hg/y	Air kg Hg/y	Water kg Hg/y	Land kg Hg/y	Products kg Hg/y	General Waste kg Hg/y	Sector Specific Disposal kg Hg/y
Dental mercury amalgam fillings	4,435	0	1,331	0	266	532	532
Manometers and gauges with mercury	52	5	16	31	0	62	532
Laboratory chemicals and equipment with mercury	2,184	218	0	1,310	0	655	0
Miscellaneous product uses, mercury metal uses, and other sources	22,800	6,840	0	0	0	15,960	0
TOTAL	**29,471**	**7,063**	**1,347**	**1,341**	**266**	**17,209**	**1,064**

Source: DENR, Mercury Assessment for the Philippines: Using UNEP Inventory Toolkit, September 2008.

As Tables 2, 3 and 4 highlight, mercury-containing waste can be a significant source of mercury releases to the environment. Waste generation in society is determined by the consumption of goods. Changing consumer preference and introduction of mercury-free alternatives could have a considerable impact in lowering mercury emissions form wastes. It also shows that control of mercury releases from these sources is literally at the tip of our hands. Proper waste management will be a key in stemming uncontrolled mercury releases from the waste stream.

3.1.1 Waste Disposal in the Philippines

It is estimated that the seventeen municipalities composing the greater Manila area or Metro Manila, generates as much as 1.95 million metric tons of waste per year.[7] Based on government data, only 73% of the 5,250 metric tons of waste generated daily are collected, the remaining 27% of the daily waste or about 1,417.5 metric tons end up in canals, vacant spaces, street corners, market places, and rivers.

In order to address the waste crisis of the late 1990s, the Philippine government enacted the Ecological Solid Waste Management Act of 2000 or Republic Act 9003 in 2001. Among the salient features of the law is the mandatory segregation of solid waste at source, e.g. household, institutional, industrial, commercial and agricultural sources.

In spite of the law, and the estimated Php3.54 billion (approx. US$ 73 million) spent annually on mixed waste collection and disposal,[8] both regular municipal waste and toxic wastes, such as wastes containing mercury, are often mixed together and end up being burned or discarded in open pits, water bodies, or simply anywhere garbage can be thrown.

The number of open and controlled dumps continues to increase, from an estimated 996 in the last quarter of 2006 to 1,185 in the last quarter of 2007.[9] These dumpsites should have been closed as early as February 2004,[10] and their increase affirms the Philippines' continuing problem with volume and non-segregation of waste.

Another challenge with the existing waste disposal system in the Philippines is the absence of accurate engineering and technical data and assessments are often made by cursory site observations and verbal site reports. [11]

Many of the dumps are located in or very near environmentally critical areas such as watersheds, national parks, ground water reserves, creeks, rivers, lakes, foreshore lands, irrigation canals, agricultural fields and communities.[12]

Among several dangers raised by dumpsites, surface and sub-surface leachate pose considerable risks seeing that the dumps take in mixed wastes, including mercury-containing wastes. For instance, based on leachate sampling in two major dumpsites, an estimated 26 kg of lead and 76 kg of arsenic is released annually into the groundwater, rivers, lakes and bay of Metro Manila.[13]

3.1.2 Management of mercury-containing wastes in the Philippines

Under Republic Act 6969, the Toxic Substances, Hazardous and Nuclear Wastes Control Act, the import, manufacture, process, distribution, use, transport, treatment, and disposal of toxic substances and hazardous and nuclear wastes in the country are to be strictly controlled. Any entity seeking to engage in the treatment, storage, disposal (TSD) of toxic wastes must be accredited by the DENR.

Based on the DENR's current list of registered TSD facilities for hazardous wastes, there are nine (9) accredited facilities in the Philippines.[14]

All of the accredited facilities are located in the main island of Luzon. There are no accredited TSD facilities for managing mercury-containing wastes in the other major islands of the Philippines. Further, the extent of the accreditation given to the nine (9) facilities with reference to mercury, only extends to busted fluorescent lamps/bulbs. None of the facilities are accredited to handle other types of mercury-containing wastes, e.g. thermometers, electrical switches, etc.

Of the nine (9) accredited TSD facilities, only two (2) are licensed disposal facilities.[15] To ensure that mercury wastes brought to landfills do not enter the biosphere, the sequestered mercury is first encapsulated in a non-porous, non-permeable material, and then placed in an engineered double-lined landfill accredited by the DENR.[16]

There is no appreciable infrastructure to collect and transport mercury-containing wastes from generators to their facilities. However, in interviews conducted with some of the accredited TSD facilities, they have the capacity to bring their bulb crushing equipment to the generator.[17]

It is noticeable with the list of clienteles by the accredited TSD facilities that all of the generators they are servicing are large businesses. There appears to be no facility that is directly managing wastes generated at the household level.

3.2 Southeast Asian Region

Noticeable in Table 1 is the row of zeroes under mercury emission from waste incineration. The reason given by the DENR for this is that Philippine law prohibits open-burning or incineration. However, legal reality is not necessarily always the same with physical reality.

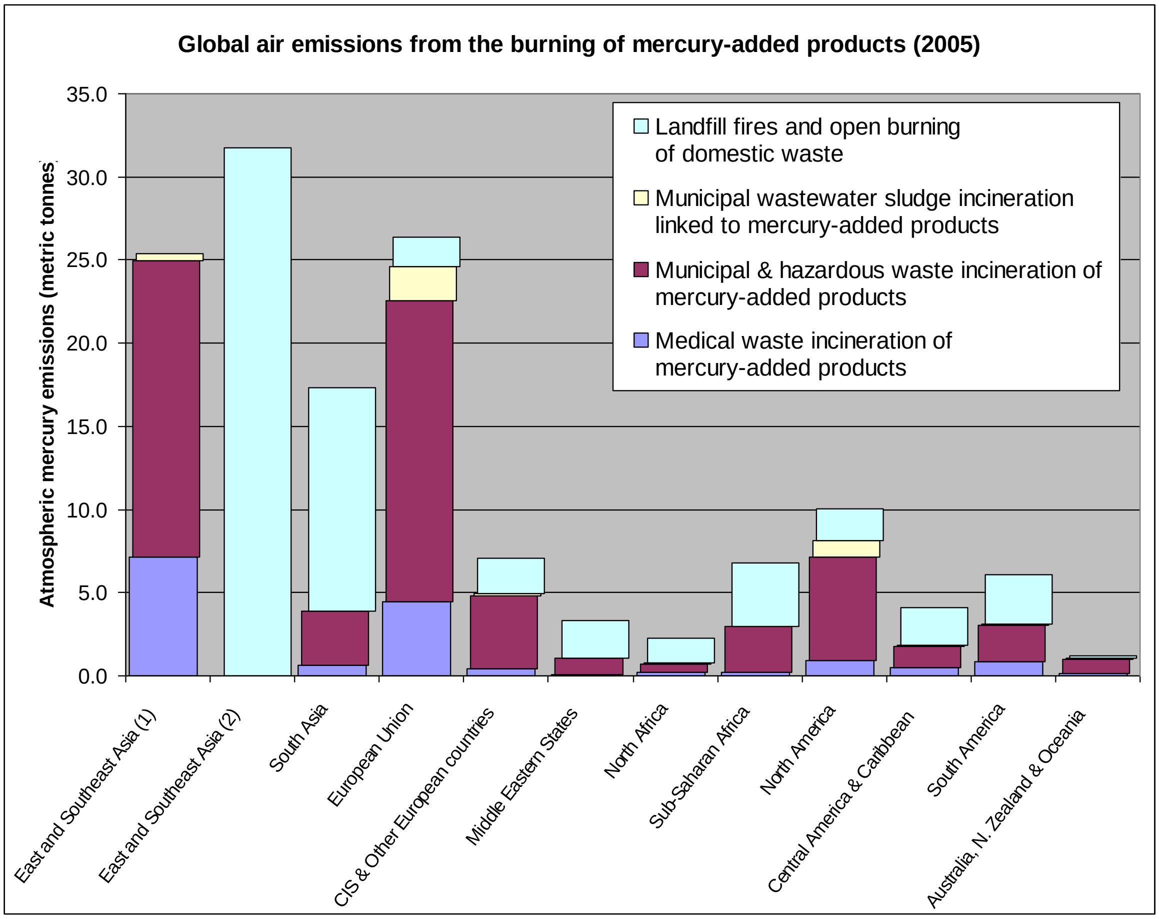
The study proponents visited several dump-sites[18] and witnessed first hand cases of open-burning, particularly of wires and electrical equipment, including fluorescent and compact fluorescent bulbs. These wastes figure prominently as waste pickers try to liberate copper and other metals from the wastes.

Mercury-containing waste incineration or burning is overlooked in the DENR assessment, and should be re-evaluated. Existing data show the continued increase in dumpsites affirming the rise in the volume of wastes, and the lack of segregation leads to the practice of regularly mixing toxic and regular municipal waste. The mixed waste eventually end up in the open pits where burning often occur to retrieve valuable materials and also to minimize volume of the waste.

The concern over the underestimation of mercury waste emissions from incineration or open-burning was reflected in a global study, released last February 2009 by environmental groups, entitled "*Mercury Rising: Reducing Global Emissions from Burning Mercury-Added Products*". The study revealed that the burning of products containing mercury contributes upwards of 200 tons of mercury to the atmosphere every year.[19]

The report looked at several burning processes: medical waste incineration, municipal and hazardous waste incineration, municipal wastewater sludge incineration, and landfill fires and open burning. The emissions from these processes is shown below by region, see Figure 2 below.

Figure 2: Global Air Emissions by Region



Source: Mercury Rising: Reducing Global Emissions from Burning Mercury-Added Products, 2009.

The level of emissions in the East and Southeast Asia region is noticeable as it far outpaces those in the other regions. The magnitude of emissions, according to the report are due to landfill fires and open burning of domestic waste which is reflective of a combination of significant open burning, especially in rural areas, a large amount of mercury consumed in products in the region, and very low recycling rates. The study also cites the fact that "even though formal incineration of municipal waste is not common in most countries in Asia, the generation of large volumes of waste, the relatively high use and disposal of mercury-added products, and the fact that Japan, in particular, incinerates a very high percentage of its waste help to explain the magnitude of regional atmospheric mercury emissions from incineration."[20]

The study data acknowledges the impact of incineration in the emission of mercury in the atmosphere. The Philippine situation may not be too far behind the regional data based on the overall context of waste management in the country seen so far.

The Philippines faces an uphill battle with the proper management of the almost 47 tons of mercury waste from products and processes it generates per year. The following section examines the options available to the Philippines that are presently being observed around the world to manage mercury-containing wastes.

4. Terminal Storage Options for Mercury and Wastes Containing Mercury

4.1 Defining Terminal Storage

A loose definition of terminal storage can be made based on its goal - a facility created and maintained indefinitely to store sequestered mercury to ensure that mercury is not reintroduced into the environment.

The rationale for this type of facility is based on the unique challenges that mercury poses. Like any substance or waste it may be possible to recycle mercury waste, particularly elemental mercury, in special facilities which have the advanced recycling technology especially for mercury waste. However, mercury would be released during the recycling process because of its ability to easily volatilize at room temperature. Recycled mercury could further escape once sold on the international commodities market, where it re-enters the environment, mostly in developing countries. In order to stop cycle of mercury in society, countries have initiated and developed environmentally sound management terminal storage of mercury wastes, such as aboveground, monitored and retrievable secure storage.

The move towards terminal storage of mercury has been acknowledged and has been pushed under the United Nations Environment Programme Governing Council (GC) decisions. In decision 24/3 adopted by the twenty-fourth session of the GC/Global Ministerial Environment Forum on 9 February 2007, the GC established mercury supply reduction as a global priority, and urged governments "to gather information on the options and solutions for the long-term storage of mercury".

4.1.1 Issues for Consideration

In determining which terminal storage options to pursue, governments considered a myriad of issues and these may be grouped in several categories, as follows:

A. Scope of Storage

The first issue that needs to be resolved is "what kind of mercury wastes must be subject to storage?" Each country faces various sources of mercury of varying severity, e.g. mercury from wastes and used products, by-product mercury from industrial processes, etc. Determining the scope of what needs to be stored immediately defines and helps narrow the process.

Under this category the issue of the specie of mercury to be stored is considered, e.g. elemental, ionic, including volume, concentrations. Some countries have also taken into account the chemical-physical characteristic of the mercury to be stored, e.g. encapsulated, stabilized, inert, etc.

B. Facility Infrastructure

Under this category there are two main issues to consider: site and facility structure.

Where to put the facility is as crucial a question as what facility to build. Questions of geology, hydrology, occurrence of natural disasters (e.g. earthquakes, floods, hurricanes), accessibility, transport to the facility via road or rail, among others, need to be factored in.

Some countries have looked into the issue of whether a centralized or multiple storage facilities are needed. For countries with mercury mine sites or mercury-contaminated sites, the questions have consistently focused on the comparative advantage between selecting existing contaminated-sites (e.g. abandoned mercury mines) or a mercury-free site.

Facility structure issues generally touch on the following issues, infrastructure capacity including building materials, leachate prevention, monitoring systems, long-term documentation, etc.

C. Legal

This category gets into the question of whether an existing legal infrastructure is able to support the operationalization of a terminal storage facility. Issues involving attribution of ownership of the waste and responsibility, licensing procedures, waste acceptance and documentation need to be clearly defined and delineated under law. Transition or transfer of responsibility, if any, has also been a matter of consideration, particularly at what point do the mercury generators remove themselves of any liability for the mercury they store.

Some corollary points related to this issue are who fixes the standards that must be met, and who ensures the facility or facilities are operated consistent with such standards?

D. Public Health/Environmental Concerns

At the root of the endeavor are the twin concerns of public health and the environment. Is there existing capacity to accurately map out possible environmental impacts? The evaluation of risk posed to human health needs to be fully understood as well.

E. Social/Political

The issue of terminal storage is not simply an issue of technology. There are salient and pressing social issues that accompany facilities of this nature: public acceptance, site situation near environmentally sensitive areas or indigenous people's lands, access to courts for legal redress by facility workers and affected communities, role of non-government organizations and other stakeholders, impact on minorities and gender, etc. Countries that will embark on establishing terminal storage facilities need to embrace these issues together with the technological.

F. Financial

Capitalization of the facility and the long-term monitoring of the facility are two important financial aspects. The latter is as equally crucial as the first, and the countries who have implemented terminal storage facilities have considered the latter issue closely. Who pays for the storage and who operates the storage are related to long-term financing costs. This needs to be understood and planned for well in advance.

Also at the core of these is where to source the funds for the facility. Is this is a shared enterprise or simply borne by the facility operator? Could this be subject of international aid or investments? What are the long-term sustainability options needed by the facility.

4.2 Terminal Storage Options

There are various terminal storage and disposal options existing around the world. These options can be viewed in two broad categories: above ground (e.g. warehouse) and below ground (e.g. deep rock injection). Each broad category has illustrative models. Below the study looks at what prompted the respective governments/entities to move towards terminal storage and the structure of the facility.

4.2.1 Above Ground Storage – United States Defense National Stockpile Center (DNSC)

4.2.1.1 Background

The DNSC is responsible for the management of stockpiled materials declared in excess of US defense needs. The DNSC is currently managing an inventory of mercury consisting of 4,436 metric tons stockpiled in four existing sites in the United States and has been safely storing the mercury stockpile for 50 years and are.[21]

Concerns over mercury accumulation in the environment have been slowly gaining ground in the US prompting changes in the DNSC's policies on the stockpiled mercury, resulting in the suspension of sales of elemental mercury in the open market in 1994. Not long thereafter, the U.S. Congress determined that the U.S. Department of Defense no longer needed to maintain a stockpile of commodity-grade mercury (elemental) because of the increased use of mercury substitutes and because of increases in the recovery and recycling of mercury domestically. This prompted the need for the DNSC to come up with a strategy for long-term management of excess mercury.

In 2001, the DNSC initiated an Environmental Impact Statement (EIS) process that evaluated alternatives for long-term management of mercury. The DNSC had three alternatives: (1) No action, i.e., maintaining storage at the four existing sites; (2) consolidation and storage at one of the three current DNSC mercury storage sites or at one of three other candidate locations; and (3) sale of the mercury inventory.

The EIS also contained an evaluation of the potential environmental, human health, and socioeconomic impacts of these alternatives, together with cost considerations. Other treatment technologies were considered as alternatives in place of mercury management and the DNSC concluded that "Based on the immaturity of bulk mercury treatment technologies…bulk treatment and disposal of elemental mercury is not considered viable at this time."[22]

The result of the EIS process was announced three years after, in 2004, where the DNSC made public the decision to consolidate the mercury at one location. Their decision was based on the following reasons:

- Safe long-term management. The EIS looked into the viability of the facility for 40-years and concluded that the risk of neglect or future damage is negligible.[23]
- Environmental/health risks are "negligible" to "low". For instance in calculating the risk of an accident such as a fire during a rainstorm, there was a low probability of the event. If it would happen it can occur once in 10,000 to 1 million years.[24]
- Economies of scale, minimizing costs instead of spreading cost over several facilities;
- Consistent with policies and objectives of the DNSC. Removing DNSC's excess mercury inventory is consistent with the national security mission.[25]

4.2.1.2 Facility

In 2006, the DNSC announced that the chosen consolidation facility will be located at the Hawthorne Army Depot in Nevada.
[JO: INSERT HERE FIGURE 3: Mercury Overpacking DNSC Facility]

The DNSC stockpiled mercury will be placed in a 200,000 square foot warehouse equipped with the following, among others:

- Static ventilation
- Heat, smoke, and fire detection system.
- Intrusion detection
- Active fire suppression systems
- Buildings constructed of materials resistant to fire such as concrete and steel
- All doors fitted with 3 inch containment dikes
- Installation of Terra Nap flooring and ramps[26]

Routine inspections play a key to the safety and security of the facility. The DNSC utilizes state-of-the-art Lumex and Tekran mercury air-monitoring equipment which are able to detect mercury in parts per billion.[27]

The DNSC facility is a closed facility, as it only caters to the Department of Defense stockpile and is not open to accept mercury from outside sources.

From the foregoing, for long-term storage of mercury in above ground facility, it is important to build the warehouse at which there is almost no effect of natural disasters, e.g. earthquake, typhoon, hurricane, flood, etc. or on ground strong enough to withstand natural disasters. Also, the facility needs to be built far away from residential areas as a safeguard against accidental mercury spillage or mercury spillage by natural disasters.

4.2.2 Below Ground Storage – European Union, Sweden

4.2.2.1 Background

On 5 September 2008, the European Union passed Regulation (EC) No 1102/2008 (EU Regulation) on banning of exports and safe storage of metallic mercury (Regulation). In enacting the Regulation, the EU recognized the threat posed by mercury and the need to reduce risk of mercury for humans and the environment. Reducing global mercury supply was identified by the EU as a goal and banning exports of mercury from the EU would work towards this goal. In pursuing this strategy the EU anticipated the increase of mercury supply in the EU as a result of its export ban. To address this, the EU spelled out the need for safe storage of the surplus mercury.[28]

The EU Regulation clearly defines what it considers permanent storage when it provides that:

a) with the proper containment, mercury waste can be temporarily stored for more than one year or permanently stored in salt mines adapted for the disposal of metallic mercury, or
b) in deep underground, hard rock formations providing a level of safety and confinement equivalent to that of those salt mines.[29]

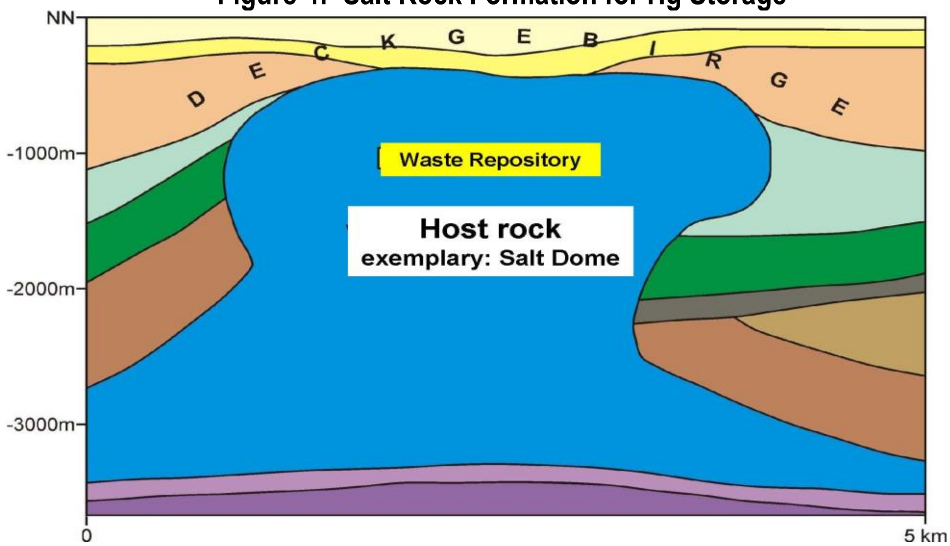
The EU Regulation considers above ground storage as temporary.[30]

4.2.2.2 German Salt Mines

The concept of this method is to place mercury waste in the cavities of disused, excavated area of a salt mine, remote from the mineral extraction part. According to K+S Entsorgung GmbH, the German company running the salt mine facility the stable cavities of salt mines offer the safest, as well as the environmentally most responsible solution for the disposal of hazardous wastes, such as mercury waste. The surrounding rock salt mass provides a seal against liquids and gasses because the layers surrounding the rock salt mass and the covering layers reliably seal the rock salt layer against any intruding moisture.

Further, the company points to the geological conditions in which the mines are situated in, which have remained stable at each site for more than 200 million years, guaranteeing an intact rock salt layer.

Figure 4: Salt Rock Formation for Hg Storage



Source: Th. Brasser, GRS

The storage areas of an underground waste disposal plant are positioned lower than any ground water reservoirs, and typically have no humidity. In addition to natural barriers, artificial barriers are used. For example, the entrances to the separate storage chambers are closed by dry brick walls or by rock salt fillings. Wastes, which are stored underground in this way, are not subjected to the sometimes significant dissolution and transport processes, such as are often the case in above-ground storage.

Aside from the advantage of a natural barrier, the other advantage of an underground waste disposal plant is the fact that above-ground space is left to other, more fitting uses. This is especially useful for countries with small landmasses.

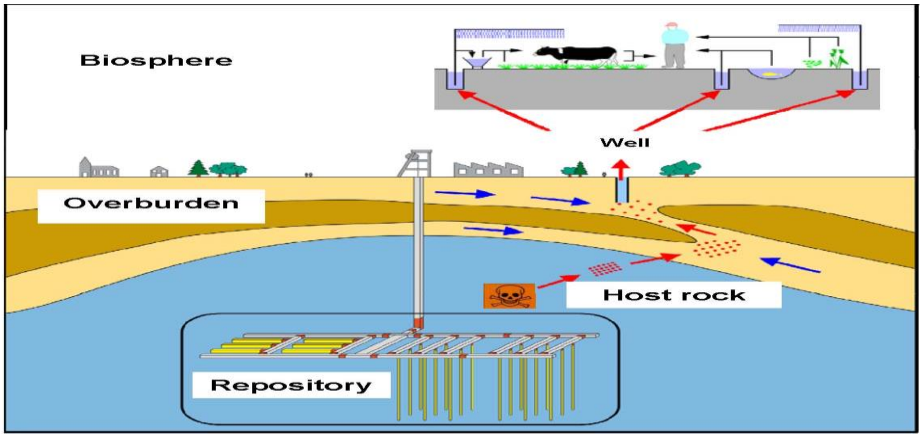
All wastes intended for storage in K+S Entsorgung GmbH facility need to undergo an individual approval procedure. There are no across-the-board clearances, so each waste has to be inspected before the facility accepts it. Within the scope of these approval procedures for a specific type of waste the chemical composition, as well as all physical, chemical and toxicological characteristics of the waste need to be examined.

The facility does not accept the following wastes: explosive, self inflammable, infectious, radioactive, capable of releasing hazardous gases, liquid, and bearing risk of increasing their volume.[31] The facility is open to outside sources for a one-time fee. The cost considerations will be discussed separately in the section on Cost.

Since this is an underground facility, the most important criterion for work safety is the monitoring of the ventilation and aeration system, particularly in reference to hazardous particles in the air. This monitoring is effected by gas detection instruments, by internal measurements at the separate work stations, and also by external auditing agencies.

The underground waste disposal plants are certified as “Entsorgungsfachbetriebe”, which means that they are approved disposal facilities according the German regulations. The capacity of the salt mines,

FIGURE 5: Underground Disposal System Scenario



Source: Th. Brasser, GRS

according to the firm is sufficient for many decades to come.

4.2.2.3 Deep Rock Injection – Sweden

Like the other governments previously mentioned, the Swedish government acknowledges the dangers of mercury and has adhered to the policy of ultimately removing mercury from the ecocycle instead of recycling, in its approach to mercury.[32]

Other key policy considerations taken into account were:

- Storage will reduce the stress placed by mercury on the environment and keep it in the minimum level in the long term.
- The storage facility should not be a burden on future generations.[33]

In 1994, the Swedish Environmental Protection Agency was tasked of formulating proposals for the terminal storage of waste containing mercury. The Agency concluded that it was reasonable to store waste containing at least one per cent mercury in a deep bedrock repository. This would cover most mercury waste, but not low level mining waste for instance.

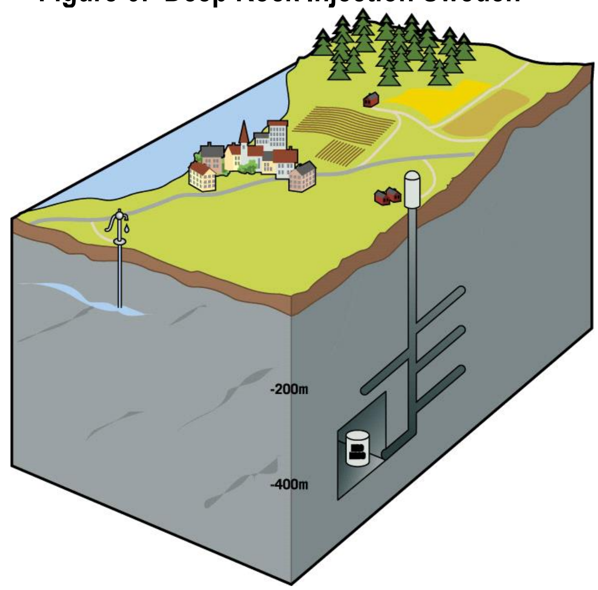
Based on the Agency’s report, the Government subsequently appointed a committee to further look into, in consultation with the waste owners, on how to proceed in bringing about a permanent storage for mercury waste. An official report was released in June 2001.

The Swedish conclusion is that a terminal storage deep down in bedrock is the best solution to deal with mercury waste. The Swedish solution took from their experience and more than twenty years of research regarding a terminal storage in bedrock for nuclear waste.

According to the Report, storage underground in deep bedrock relies on the capability of nature itself, in the form of the surrounding bedrock, to provide protection of the waste. The concept is very similar to the German Salt Mines, the main difference being the German facility relies on unused and excavated cavities. The Swedish model will be placing their repository possibly in a new site.

Another difference is in the setup of the operating facility. The Swedish solution follows the polluter pays principle, thus it must be stressed that the responsibility for building and operating a storage facility, including the necessary surveys and technical development, should rest on the waste owner or operating facility, e.g. a waste management company, who is prepared to do it for them. The role of government is to guide the process in the right direction and set up the frames for the activities. This also follows Sweden's approach to nuclear wastes.

Figure 6: Deep Rock Injection Sweden



Source: Björn Södermark, Swedish Environmental Protection Agency

Financing for the facility will be derived from the owners with partial help from the government. The Swedish Report recognizes the ambitious nature of the project, however, and concedes that due to cost consideration it may not be necessary to store all mercury waste in deep bedrock, and that some could be kept in above ground storage.

4.3 Disposal and Other Methods

Aside from terminal storage there are prevailing practices on the management of waste mercury and upcoming technologies which are being considered.

4.3.1 Landfilling

As mentioned earlier, several TSD facilities in the Philippines are putting the collected mercury wastes into landfill. The study does not have access to the technical data of the landfills in which the mercury wastes are disposed to.

In this regard, the study refers to the Basel Convention Technical Guidelines on Specially Engineered Landfill (Technical Guidelines). According to the Technical Guidelines a specially engineered landfill should be used when disposing mercury-containing waste to the landfill site.[34] Landfill sites should be completely shut off from the outside natural world. The entire landfill is enclosed in watertight and reinforced concrete, and covered with the sort of equipment which prevents rainwater inflow such as a roof and a rainwater drainage system, see figure below.[35]

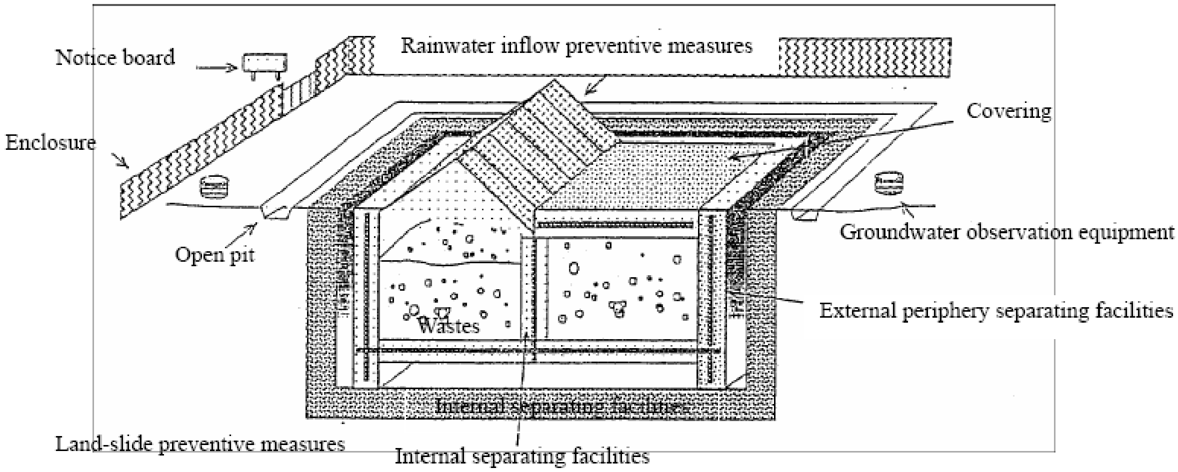


Fig. 7: Specially engineered landfill (Source: Basel Convention Technical Guidelines)

For further information about specially engineered landfills please refer the Basel Convention Technical Guidelines on Specially Engineered Landfill.

4.3.2 Stabilization

The Swedish waste management company SAKAB AB, together with the German company DELA GmbH, have the goal to develop a technology for stabilisation of liquid mercury in accordance with the timetable set for final disposal of mercury within the European Union. DELA GmbH has previous experience with a well proven technology for the treatment of mercury sludge, by using specialised equipment including a vacuum mixer. This technology has been adjusted by DELA to be suitable for the stabilisation of liquid mercury with sulfur, to produce the natural mineral cinnabar. The process is a stoichiometric conversion by good mixing and adjustment of the optimal conditions for the reaction between sulfur and mercury, resulting in a sparingly soluble solid mercury product. The process generates approximately 1.4 tons of end product from one ton of metallic mercury. The end product from the stabilisation is cinnabar, which is the original, natural mineral form, sparingly soluble, solid and therefore suitable for final disposal. A pilot plant with a capacity of 500kg/day has been operated by DELA. A full-scale plant with a treatment of 4 tons per day is planned, however, due to market concern, the development has been put on hold until circumstances change.[36]

4.3.4 Export

Mercury wastes are covered under the Basel Convention on the Transboundary Movement of Hazardous Wastes and their Disposal.[37] Any export of mercury wastes must comply with the Basel Convention requirements, including but not limited to the prior-informed consent of the importing country, and in cases toxic waste exports from developed to developing country, the Basel Ban Amendment.

4.4 Cost Considerations

The cost considerations discussed below are of little use for comparative purposes, since the assumptions and qualifications are so varied from one method to the next. Taken as an informational guide, however, the data presented could provide a general framework for the costs that can be expected from a range of mercury waste management options.

Further, it is worth noting that the costs below have relatively little connection with the volume of mercury to be stored or disposed of. Most of the cost is related to the capitalization phase which is the development of the site and facility. If there are pre-disposal mercury treatment costs, which are directly related to the volume of waste treated, the costs could be higher.

4.4.1. Above-Ground Storage Cost

Regarding relevant storage and consolidation costs of storing 4, 436 metric tons of commercial grade elemental mercury, the DNSC incurred:

One-Time Costs at Hawthorne Terminal Storage Facility (US$)[38]

Construction	3,875,000
Process Hazard Analysis	383,000
Material Receipt/Stock Positioning	692,000
Install Fire Suppression	4,200,000
Mercury Flask Inspection	7,000,000
Transportation	1,300,000
Total One-Time Cost	17,450,000

Recurring Costs at Hawthorne Terminal Storage Facility (US$)[39]

Storage – Includes inspections and normal facility maintenance
Restoration – Major repairs, minor construction for buildings
Maintenance – For the equipment DNSC installed in the warehouses including the fire detection and suppression systems, flooring, ramps, testing equipment and material handling
Inspection – periodic for leakage
Total Recurring Cost $547,904/yr + inspection X acceleration at 3.5%/yr

4.4.2 Deep Rock Injection Cost

The Swedish EPA report estimated the cost of a deep bedrock repository having a capacity of about 1,000 – 20,000 tonnes of high-level mercury waste to be about SEK 200 – 300 million (approximately US$25 to 37 million). This represents a cost of approximately SEK 250,000 – 650,000 (US$ 31,000 to 81,000) per tonne.

In addition to the cost of the repository itself, there will be the cost of any processing and stabilisation. Since prior stabilization is required before storage of the mercury waste, this intermediate cost is incurred. The consultants' report suggests that the cost will typically be SEK 10 – 20 (US$ 1-3) per kilo. The Swedish Report acknowledges that this may involve SEK 250 million (US$ 31 million), almost the same cost of the repository itself. Thus, bearing in mind the costs involved in deep bedrock injection, there are compelling reasons to keep costs down while still meeting safety requirements. Responsibility for finding optimal solutions of this kind rests with the waste owners.[40]

4.4.3 German Salt Mine Cost

There are two components to the cost of storage in the German salt mine facility: one time storage fee and transportation costs. According to According to K+S Entsorgung GmbH, a one time fee of €270 / tonne will be charged. The transportation cost to the facility will vary greatly depending on location and volume of waste (including permitting costs).

4.4.4 Cost of Disposal and Other Methods

4.3.4.1 Landfilling

Specially engineered landfills are generally costlier than regular landfills and the cost is dependent on many variables, such as capacity, location, types of wastes, etc. In computing for the cost, however, the following should be included: general land area needs, locations, design, operation, closure, aftercare, financial guarantees for potential damages to third parties, and remediation.

4.3.4.2 Stabilization

No cost has yet been established for the SAKAB AB and DELA facilities. However, the Swedish Report estimates that stabilization will cost will typically be SEK 10 – 20 per kilo acknowledging that this may involve SEK 250 million for 1,000-20,000 tonnes of mercury waste.

4.3.4.3 Export

The export cost would be determined by the cost charged by the facility taking in the waste and the transportation cost. A specific amount will be difficult to estimate given the many variables to arriving at this cost, e.g. type of waste, volume, location, permitting costs, etc.

Table 5 : Cost Reference

Facility	Capacity	Accpetance Criteria	Start-up Cost	Recurring Costs
US DNSC	4,436 metric tons	Accepts only US DOD mercury	US$ 17.5 Million	US$547,904/yr
German Salt Mines	"sufficient for many decades to come" *	No blanket criteria; Each waste inspected	€270 / tonne + cost of transport	None
Sweden Deep Rock Injection	1,000 – 20,000 tonnes	Accepts only Swedish waste; Mercury limit	US$25-37 million	None

* As per information from K+S Entsorgung GmbH

5. Philippines Laws

The 1987 Constitution of the Philippines outlines the State's policies on public health and environment that forms the basis for environmental regulations in the Philippines. The Constitution calls for the government to protect and preserve the right to health of Filipinos and mandates the government to protect and advance the right of the people to a balanced and healthful ecology.[41] These policies gave rise to various environmental enactments

5.1 Law on Mercury

Republic Act 6969 or otherwise known as the Toxic Substances, Hazardous and Nuclear Wastes Control Act (RA 6969) and its ensuing regulations is the cornerstone of the current mercury legislation in the Philippines.

RA 6969 was designed to respond to the heightened problems associated with the dumping of toxic chemicals and hazardous wastes by developed nations on poorer countries in the 80's. To address these concerns the law covered a wide range of activities, namely: importation, manufacture, processing, handling, storage, transportation, sale, distribution, use, and disposal.[42]

In 1992, the Department of Environment and Natural Resources (DENR) who is tasked to enforce RA 6969, released Administrative Order 1992-29, known as the Implementing Rules and Regulations of Republic Act 6969 (IRR). The IRR expands on the provisions of the law and clarified certain processes and responsibilities on chemicals, hazardous and nuclear wastes. The IRR clarified the scope of the law by creating a list of wastes classified as hazardous under RA 6969 and subject to its control. Mercury and Mercuric Compounds (D407) were identified in the list and clearly placing these substances under the ambit of RA 6969.

The IRR also elaborated on several policy points on hazardous wastes, three of which are of relevance to terminal storage of mercury waste:

1. In the management hierarchy of hazardous wastes priority should be on the minimization of its generation, followed by its recycling, treatment to render it harmless, and landfilling of hazardous wastes;
2. Waste generators are responsible for the proper management and disposal of their hazardous wastes;
3. Waste generators shall bear the cost for the proper treatment, storage, and disposal of their hazardous wastes; and
4. Ownership of the hazardous waste remains with the generator until the hazardous waste is certified to have been treated, recycled, reprocessed, or disposed of the designated waste treater.

The IRR exempted garbage from domestic premises and households from its coverage.

In 1997, the DENR to further issued rules on the control of mercury, particularly Administrative Order No. 97-38, Chemical Control Order for Mercury and Mercury Compounds (CCO).

The CCO created additional requirements for entities dealing with mercury or mercury-containing compounds, such importers, manufacturer, distributors, treaters, transporters. One of the new requirements coming out of the CCO is the imposition on limits on who can use mercury in the

Philippines.[43] Under the CCO only the following industries are allowed to bring in mercury into the country:

a) Chlor-alkali plants;
b) Mining and metallurgical industries
c) Electrical apparatus (lamps, arc rectifiers, battery cells, and others)
d) Industrial and control instruments
e) Pharmaceutical
f) Paint Manufacturing
g) Pulp and Paper Manufacturing
h) Dental Amalgam
i) Industrial Catalyst
j) Pesticides (fungicide) production or formulation

The CCO also made it explicit that no mercury bearing wastes will be discharged to the environment without prior DENR approval. Lastly, the CCO linked the liability of the importer and distributor of mercury and mercury-containing compounds with the end-user in cases of injury, damage to public health and environment.

RA 6969, its IRR and CCO have shown farsightedness on the part of the DENR in attempting to deal with mercury. Notably control mercury from its import/manufacture to disposal shows a degree of understanding and appreciation of the dangers of mercury. With new research and practices arising out of the global effort to combat mercury, it would be an opportune time to evaluate RA 6969 and its regulations on how it measures up in operationalizing terminal storage in the Philippines.

5.2 Related Laws

There are other laws that directly or indirectly regulate mercury use and emissions in the Philippines:

a) Presidential Decree No. 984 (Pollution Control Law of 1976)
b) Presidential Decree No. 1586 (Environmental Impact Assessment System Law of 1978)
c) Republic Act 8749 (Clean Air Act of 1998)
d) Republic Act 9003 (Ecological Solid Waste Management Act of 2001)
e) Republic Act 9275 (Clean Water Act of 2004)

6. Discussions and Recommendations

6.1 Trends

6.1.1 Philippines

The Philippines is becoming a leader in the Southeast Asian region, on the issue of mercury. It is the first country in the region to phase out mercury-containing devices and equipment in all healthcare facilities in the country. The Department of Health issued Administrative Order 21 (AO 21) last August 11, 2008 mandating all hospitals to follow the guidelines for the gradual phase out of mercury in two years. The first mercury-containing equipment targeted under AO 21 are mercury thermometers, all hospitals are required to discontinue the distribution of mercury thermometers in the patient's admission/discharge kits.

Another salient provision of AO 21 is the requirement to all new health care facilities applying for a license to operate to submit an inventory of all mercury-containing devices that will be used in their facilities and a corresponding mercury elimination program.

Waiting at the wings of AO 21 are pending legislative bills calling for the phase out of mercury in schools.[44]

Philippine non-governmental organizations (NGOs) have also been very active on this issue. Foremost of this is Health Care Without Harm Southeast Asia who pioneered the issue on the removal of mercury in hospitals, and has done and continues to do groundbreaking work on this issue.

The pro-active stance taken by the Department of Health and the vibrancy of the Philippine NGOs assure that mercury phase outs will not peter out in the immediate future.

6.1.2 Asian Region

Last March 4-5, 2009, the United Nations Environment Programme (UNEP) together with the international NGO coalition, Zero Mercury Working Group, organized a multi-stakeholder workshop entitled Asia Mercury Storage Project Inception Workshop (Workshop) that saw the participation of seventeen Asian governments, eight United Nations bodies, and six international and local NGOs.

The Workshop was aimed at reducing the eventual supply of mercury to the biosphere by initiating a regional process that will support the sequestration of excess mercury in the Asian Region. During the workshop a study on mercury supply and consumption in 2005 and projections for 2050 in Asia was delivered. [45]

The study demonstrated that the Asian region is a significant net importer of mercury and at present the vast majority of the imported mercury is used for small-scale gold mining. The study concluded that substantial excess mercury can be expected in Asia after 2030 approximately just over 5,500 – 7,500 tonnes after phase outs and other control measures are applied.

As a result of the discussion at the Workshop a regional advisory body represented by an Executive Committee (Execom) was created and tasked to catalyze regional action in the sequestration of excess mercury in Asia, communicate issues, and recommend appropriate legislation. With the creation of the Execom, work towards an Asian regional facility on the terminal storage of surplus mercury is underway.

6.1.3 Global Trends

6.1.3.1 EU and US Export Ban and Terminal Storage

2008 was a banner year for international action against mercury. First of these are the announcements coming from the European Union (EU) and the United States of their intent to address the supply of mercury by enacting an export ban against mercury. The EU ban covers elemental mercury and will take effect in 2011 and also requires that the remaining surplus of mercury needs to be put into safe storage as of the same date.[46]

The US ban also covers elemental mercury and is to take effect in 2013. Notably, the United States also linked up the establishment of terminal storage facility for domestically generated mercury, requiring the Department of Energy to designate a facility by 2010.

40 to 50% of the annual global trade in mercury passes through the US and EU.[47]

6.1.3.2 UNEP Governing Council Decision on Mercury

Last February 16-20, 2009 during the 25th Governing Council of UNEP (GC 25) issued a landmark decision on mercury where the world governments have agreed on moving forward with a legally binding treaty on mercury, and directing the Executive Director of UNEP to convene an international negotiating committee (INC) by 2010.[48]

Part of the INC mandate is to develop a comprehensive and suitable approach to mercury including provisions on the reduction of supply and the enhancement of environmentally sound storage. The GC decision further called on the need for coordinating approaches in the international action against mercury that includes the area of enhancing capacity for mercury storage.

GC25 above sets a strong tone on increased and concrete international action on mercury.

6.1.3.3 UNEP Global Mercury Partnership (GMP)

The UNEP GMP is considered the vehicle for delivering interim actions to fulfill UNEP GC Decision 25/5. Partnership activities are currently underway in the following partnership areas (with the respective partnership leads): artisanal/small-scale gold mining (UNIDO); coal combustion (International Energy Agency Coal Centre); chlor-alkali sector (USEPA); reduction in products (USEPA); fate and transport (Italy); waste combustion (Japan).

The partnership areas establish specific goals and actions to address needs and contribute to the overall goal of the UNEP GMP. Membership varies according to interest. A Partner supports the overall goal of the Partnership, commits to contribute resources or expertise towards the development and implementation of partnership activities, and networks with other organizations/agencies/ individuals.

Mercury supply and storage is currently identified as a potential partnership area. A draft business plan was proposed by UNEP in 2008.

6.1.3.4 EU Chlor Alkali Sector Terminal Storage

The European Commission welcomes a voluntary agreement announced last December 22, 2008 to ensure the safe storage of surplus mercury from the European chlor-alkali industry, once a ban on exports of the highly toxic metal from the European Union takes effect.

Euro Chlor, the European business association representing chlor-alkali producers in the EU and the European Free Trade Association regions – the chemical industry sector responsible for chlorine and caustic soda production – has pledged to ensure safe underground storage of mercury surpluses from the industry once this ban takes effect in 2011.

Euro Chlor has voluntarily agreed to remove surplus mercury from decommissioned chlorine plants, and to transport these to its final destination in approved sealed steel containers and stored, preferably in deep underground salt mines.

Approximately 9,000 tonnes of liquid mercury are remaining in European chlorine plants will be affected by this voluntary agreement.

6.2 Recommendations

Mercury poses a multi-faceted challenge to many nations, more so to a developing country such as the Philippines. As discussed in previous sections mercury from human sources are varied, from its release through coal combustion to the very products that society has grown to rely on that eventually become wastes. Developing countries are forced to look at environmental and health problem whose toxicity has no half-life, a toxin that is simply immortal.

The idea of sequestering the releases of this toxin and storing it permanently is simply revolutionary and demands a multi-faceted and full life-cycle approach. In order to this, the Philippine government needs to abandon certain biases on regulation and view terminal storage, its implications and demands, as a facet of a comprehensive approach and not an end in and of itself.

A. Creation of a comprehensive national policy on mercury with a provision for terminal storage

A comprehensive national policy on mercury is needed in order to thread together the disparate areas of environment, public health, and trade that the mercury issue straddles. A national policy also serves as a guide post for the development of a legal infrastructure to support the policy and for government enforcement.

For instance, in the waste management hierarchy for waste under the IRR of RA 6969, recycling and reuse of waste is prioritize while terminal storage is not even acknowledged. For regular wastes this may be apt, but in the case of mercury, recycling or re-using only increases the probability of its eventual release.

There are also gaps in addressing mercury at source. Under the CCO, there is still a favorable presumption given to certain industries by allowing them to import mercury into the country, e.g. mining and metallurgical industries. Under the DENR recent inventory it has been shown that major emissions in the Philippines come from gold-mining operations. Knowing that the major source emission comes from the mining industry then a prohibition on imports by these sources must be put in place.

The demands of such comprehensive national policy would necessitate the inclusion of the following elements:

1. Terminal Storage as Part of Waste Management Policy

   The IRR and CCO do not recognize terminal storage as an option in the environmentally sound management of mercury wastes. The government needs to reorient its policy on waste management with respect to mercury. The government needs to look at prevention and minimization, storage, types of treatment or stabilization of mercury, and disposal methods. Recovery or recycling mercury waste operations should be guided by the policy-makers such that the process does not undermine policies set to protect human health or cause harm to the environment.

2. Controlling the supply of mercury

   As an importer of mercury and mercury-containing products, the Philippines is becoming a mercury sink. At the products end-of-life or if the imported mercury is no longer needed, the Philippines must ensure that Filipinos are not being burdened by foreign mercury coming into the Philippines. Thus, the task is not simply to monitor the amount of mercury coming in but to phase out sources and prohibit elemental mercury and mercury contained in other sources, e.g. those contained in products, that are not necessary or which have mercury-free alternatives.

   The government cannot simply focus on end-of-pipe solutions but it must clearly close the tap supplying mercury into the country. This policy benefit end-of-pipe solutions such as terminal storage, as it indirectly sets up limits to the amount of mercury that needs to be dealt with at the disposal stage.

3. Controlling the demand of mercury

   Controlling the supply without controlling the demand would be akin to locking the front door against thieves and leaving the back door open instead. Control on the supply side of mercury will be very difficult to achieve without the necessary control on demand.

4. Trade Restrictions on Products and Technologies/Processes Promoting Mercury

   There has to be a clear policy statement acknowledging the necessity of utilizing trade restrictions as a tool to containing the mercury problem. Twenty percent of the estimated releases of mercury in the Philippines comes from intentional releases from products and wastes, trade restrictions on products and processes/technologies that rely on mercury is an appropriate and necessary measure to protect public health and the environment.

5. Fiscal Incentives to Hg-Free Industries/Products

Much like the interplay of the Supply-Demand control mechanism, the trade restriction measure should be accompanied by fiscal incentives for companies or industries. The government must adopt a policy that cultivates investments and provides incentives to entities that engage in the manufacture or distribution of mercury-free alternatives.

6. Promotion of Alternatives/Substitution

   In the course of this study, the proponents have come to realize that there is still much lack of awareness among the population of the dangers of mercury and the existence of mercury-free alternatives. The Philippine government must reiterate its policy towards awareness raising on mercury, but must include promotion of alternatives or substitutes as well.

7. Multi-Stakeholder Process

   An integral part to the success of the various efforts on terminal storage is the inclusion of all affected parties in the discussion of a path towards terminal storage.

8. Provide current and relevant information on mercury; Ensure access to such information; and proper risk communication

   The government needs to re-affirm the importance of the public's access to relevant and current information on mercury and its duty to develop and furnish that information to the public. It is also crucial for government to provide advisories on mercury levels or pollution especially to populations sensitive to mercury.

B. Creation of a cohesive legal infrastructure to support the national policy on mercury

Existing laws possess a range of measures for the establishment of disposal facilities that is applicable to mercury wastes, for instance Presidential Decree 1586 which requires an Environmental Impact Assessment System be undertaken before any disposal facility is set up. However, these laws are inadequate to thread the pieces of a national policy together that includes terminal storage. In this regard, there are legal gaps that need to be filled:

1. Comprehensive measures to address the intentional anthropogenic sources of mercury in the Philippines

   The CCO was enacted in 1997, a full decade before all the present understanding of mercury came about. It is understandable that the legal tools employed under the CCO are insufficient and lacks the breadth needed to complement the envisioned national policy on mercury. A new law must contain measures that would help operationalize the policy on mercury, such as, banning imports of mercury-containing products or processes / technologies that uses mercury, providing fiscal incentives for companies that manufactures or distributes mercury-free alternatives, etc.

2. Designate terminal storage as an environmentally sound solution for mercury wastes

Mercury wastes needs to be taken ultimately to a permanent repository or terminal storage facility. The law must place terminal storage in the right hierarchy of waste management and the need to take mercury wastes for terminal storage must not be an optional responsibility.

3. Modify existing exemptions on end-users of mercury

   Allowing major users of mercury such as chlor-alkali plants and metallurgical and mining industries runs counter to the very need for controlling releases. This also creates a perverse incentive for these users to continue using mercury. This exemption clearly needs to be abandoned.

4. Full prohibition on the discharge of mercury-containing wastes into the environment

   The present wording of the CCO prohibiting the discharge of mercury-containing wastes into the environment unless permitted by the DENR implies that there are justifiable causes to release mercury into the environment.[49] Given the well of data pointing to the impact of mercury on wildlife, the environment and public health, there appears to be no salient reason to allow releases of mercury to the environment. Modifying the existing language will also remove any possible interpretation that there is an opening to the discharge of mercury-containing wastes.

   Since mercury-containing wastes are household wastes, it would prudent to include household wastes in the remit of any new law that will cover mercury.

5. Expanding the responsibility of generators/distributors of wastes

   The CCO rightfully contains provisions that hold importers, distributors, and end-users liable for injury or damages caused by the improper disposal of mercury-containing wastes. Instead of relying on monetary indemnification, any proposed law on mercury, must include the responsibility of the importer, distributor, manufacturer to take-back their products containing mercury and hold them responsible for the storage of such wastes. This is known as extended-producer responsibility or EPR.

   EPR has two distinct features. First, it creates a disincentive for manufacturers or distributors to sell mercury-containing equipment, and thus cultivate the use of alternatives. Second, it rightfully includes the manufacturers or distributors in addressing the resultant problems caused by their products.

6. Clarifying roles and jurisdictions of the Departments involved in the national policy on mercury

   A national policy that extends into the areas of trade, environment, and health requires proper coordination among different agencies. The CCO is ill-equipped to delineate the roles and jurisdictions of the respective agencies. It is crucial that this be done especially in addressing products and waste issues to avoid any conflict between departments, especially, if one department wields more influence than the other.

C. Choosing an appropriate terminal storage option

Based on cost considerations it would seem that exporting Philippine mercury wastes to the German salt mines would be the most reasonable approach. Be that as it may, whatever option is chosen must still be consistent with a national policy on mercury. In choosing a terminal storage option, aside from the criteria mentioned in Section 4.1.1, the following should be taken into account:

1. Creation of a multi-stakeholder process to review options and recommend an option

   At the end of the day, the government needs to make a determination on which terminal storage option is suitable for the country. In order to do this, a multi-stakeholder body needs to be created to review existing options based on specific criteria. The need to involve the various sectors in this process acknowledges that wide impact mercury has. These interests need to be properly represented and heard to validate the option that will be chosen.

2. Social Dimension of the problem

   The issue of mercury pollution and releases is not merely a technological issue. There is a social dimension to the mercury pollution that needs to be addressed, and in choosing a terminal storage facility these dimensions have to be dealt with:

   i. Lax Implementation of Laws

      The CCO's initiative on record keeping and monitoring provided an excellent opportunity to track mercury-containing wastes as far back as 1997. Unfortunately, implementation of the law has been lax, and only some information has been gathered in the ten years since the CCO was passed. The same mistake must not recur on any new comprehensive initiative on mercury.

   ii. Poverty and Corruption

      The illegal sale of mercury in the Philippines and its heavy use in the small-scale artisanal gold mining (ASM) sector are critical issues that underpin the need for terminal storage options.

      With the confluence of factors, such as high poverty rate in the country that could drive more people into the mining sector, availability of mercury through illegal channels, and the ensuing surplus mercury through government plans to phase out mercury from use and existing stocks, could very well end up in the ASM sector if oversight is not immediately applied to phase out efforts.

- END -

[1] UNEP Mercury Global Assessment, 2002 [hereinafter UNEP GLOBAL ASSESSMENT].
[2] UNEP GLOBAL ASSESSMENT.
[3] UNEP GLOBAL ASSESSMENT.

[4] DENR Administrative Order No. 38, Environmental Management Bureau, Quezon City, Philippines [hereinafter DENR ASSESSMENT].
[5] DENR ASSESSMENT.
[6] The table derived from the DENR ASSESSMENT contained what appears to be incorrect sums - in each row and down each column. The table in this Report reflects the correct sums based on the data from the DENR Assessment.
[7] National Solid Waste Management Commission, "Managing our Solid Waste: An Overview of the Ecological Solid Waste Management Act" available at: http://www.emb.gov.ph/eeid/ESWM.htm.
[8] Asian Development Bank, The Garbage Book: Solid Waste Management in Metro Manila, 2004, p. 54. [hereinafter ADB GARBAGE BOOK]
[9] Data released by the National Solid Waste Management Commission (NSWMC).
[10] Sec. 15, Republic Act 9003,
[11] ADB GARBAGE BOOK, 36.
[12] Findings of the EcoWaste Coalition - Metro Manila's garbage is dumped in either in Rodriguez Waste Disposal Facility (located inside Proclamation 1636, a protected area in Rizal), Payatas Disposal Facility (a kilometer away from the La Mesa Watershed) and Pier 18 and Tanza Waste Disposal Facility (foreshore areas of Manila Bay). Outside Metro Manila, the Talisay City "Sanitary" Landfill is located inside the Central Cebu Protected Landscape. The so-called Norzagaray Sanitary Landfill in Barangay San Isidro (which is part of the City of San Jose del Monte, Bulacan) is a kilometer away from the Ipo Dam watershed.
[13] ADB GARBAGE BOOK, 46.
[14] List of Registered Treatment/Storage/Disposal (TSD) Facilities for Hazardous Wastes, 29 February 2009, available at: http://www.emb.gov.ph/hazardous/Treater.PDF.
[15] Interview with Mr. Geri Sañez, Department of Environment and Natural Resources, February 10, 2009.
[16] Interview Mr. Sañez, 2009.
[17] Interview with Maritrans Recycler, Inc. 19 March 2009.
[18] Rosario, Cavite; Payatas and Smokey Mountain Dumpsites.
[19] "Mercury Rising: Reducing Global Emissions from Burning Mercury-Added Products" released by the Mercury Policy Project; Zero Mercury Working Group; Alliance for Incinerator Alternatives / Global Anti-Incinerator Alliance (GAIA) www.no-burn.org; and Ban Toxics!, February 2009 [hereinafter HG INCINERATION REPORT]
[20] HG INCINERATION REPORT, 48.
[21] Defense National Stockpile Center, "Mercury Consolidation Fact Sheet", 2 February 2006.
[22] United States Federal Register, Notice of Availability of a Draft Environmental Impact Statement; Mercury Management, 11 April 2003, Volume 68, Number 70 [hereinafter NOTICE EIS].
[23] NOTICE EIS.
[24] NOTICE EIS.
[25] NOTICE EIS.
[26] David Lynch, Defense National Stockpile Center, "Asia Mercury Storage Project Inception Workshop" Presentation, 4 March 2009 [hereinafter LYNCH DNSC].
[27] LYNCH DNSC.
[28] EU Regulation (EC) No 1102/2008 [hereinafter EU REGULATION.]
[29] Art. 3 (a), EU REGULATION.
[30] Art. 3 (b), EU REGULATION, states that mercury waste can be temporarily stored for more than one year in above-ground facilities dedicated to and equipped for the temporary storage of metallic mercury.
[31] Alexander Baart, K+S Entsorgung GmbH, Underground Waste Disposal, 4 March 2009.
[32] Swedish EPA, "A Safe Mercury Repository", January 2003. [hereinafter SWEDISH REPORT]
[33] SWEDISH REPORT
[34] SBC (1995a): Basel Convention Technical Guidelines on Specially Engineered Landfill (D5), http://www.basel.int/meetings/sbc/workdoc/old%20docs/tech-d5.pdf [hereinafter BASEL TG].
[35] BASEL TG
[36] SAKAB AB, Fact Sheet: Stabilization of Metallic Mercury, May 2008.
[37] Basel Convention at http://www.basel.int/
[38] Dennis Lynch, Defense National Stockpile Center, Presentation "Asia Mercury Storage Project Inception Workshop", 4 March 2009.
[39] LYNCH DNSC.
[40] SWEDISH REPORT
[41] Article II, Sec. 15 and 16, Philippine Constitution.
[42] Sec. 3, Toxic Substances, Hazardous and Nuclear Wastes Control Act, Republic Act 6969.
[43] Sec. VII, 3, DENR Administrative Order No. 97-38.

[44] Senate Bill No. 2278 sponsored by Senator Miriam Defensor-Santiago, Housbe Bill No. 05482 sponsored by Rep. Eduardo Zialcita.

[45] Peter Maxson, Assessment of Excess Mercury in Asia 2010-2050, Nov. 2008.

[46] EU REGULATION.

[47] Peter Maxson, MERCURY FLOWS AND SAFE STORAGE OF SURPLUS MERCURY, August 2006.

[48] Draft Decision Approved by the Chemicals Contact Group, Including Mercury.

[49] Section III (3)(b), Administrative Order No. 97-38, Chemical Control Order for Mercury and Mercury Compounds.