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Generation and Management of Hazardous Wastes in Myanmar

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Abstract

Nearly 90% of the industries in Myanmar are small and medium scale industries- 60% of industries from food and beverages sector. In Myanmar, industrial solid waste are handled and treated together with municipal solid waste. More often than not, mixed waste contains hazardous components, which canIPEN be harmful to the environment and most of all to the workers and scavengers at the landfills and the residents in the vicinity. Less than 1% of waste is incinerated (hospital wastes and expired medicines) in Yangon and Mandalay but there are no technical standards for incineration. Mixed industrial hazardous waste is buried in to the ground or contained in concrete chambers. The willingness to pay for waste services is currently low. Many outstanding initiatives, projects and treatment options are already in place or under development in Myanmar. The paper presents the findings of SINTEF's work in relation to first generational inventory of hazardous wastes and elaborates upon the existing waste management situation which would be subsequently used an input for description of a conceptual hazardous waste treatment and disposal system; and qualitative evaluation of possible impacts of the current management practices. As a first step, the HW Project has investigated the generation of hazardous wastes in the industrial zones in Yangon and Mandalay and in the State Owned Enterprises. The project is also investigating the possible generation of hazardous wastes from other sectors such as oil and gas sector, mining industry, healthcare facilities, electronics and electrical equipment consumption, ODS, POPs etc. There is an absence of systematic database and the exact rates of hazardous waste generation is not currently available. SINTEF will be preparing the master plan for hazardous waste management in Myanmar by conducting technical baseline and feasibility studies. Regulatory and institutional framework for sustainable waste management and implementation of Basel Convention will be proposed by Norwegian Environment Agency and will be a part of the master plan.

Keywords: Hazardous waste, Inventory, Yangon, Mandalay, State owned enterprises, Master plan.

Generation and Management of Hazardous Wastes in Myanmar

Introduction

Myanmar is strategically located in the south Asia, Southeast Asia and East Asia region, sharing its border with Bangladesh, India, China, Lao and Thailand. Myanmar has a population of 60 million- more than 30% lives in urban areas. Myanmar is experiencing rapid urbanization, a growth in industrial activities and high economic growth. There is a large interest for foreign investment and industrial development in Myanmar and it is expected that the industrial growth will increase significantly in the coming years. With the increase of the production and use of chemicals growing amounts of wastes containing hazardous waste are expected.

In general, hazardous waste is any waste or combination of waste which may cause detrimental effects to environment or human health because of its specific nature such as being flammable, corrosive, toxic, carcinogenic, infectious, eco-toxic, etc. Hazardous waste can be found in different waste fractions defined by their origin e.g. the household waste, the commercial and industrial waste, waste from hospitals, waste from agricultural activities, etc. Artisanal mining activities produce important amounts of hazardous wastes. Hazardous waste mainly emanates from industrial activities, although it may differ from production process to production process.

Objective

The role of a national hazardous waste inventory depends on the stage of development of the national hazardous waste and chemical policy. In the early stages of development, the inventories are often created using basic calculations of hazardous waste generation and a review of management practices aiming at identifying priority waste streams and sources, main risks, main players, service and investment needs etc. Such inventories are called first generation inventories.

This Project has investigated the generation of hazardous wastes in the industrial zones in Yangon and Mandalay and in state owned enterprises. It is expected that industrial activities are the main generator of hazardous waste in Myanmar today, and no information is currently available. This means majority of the hazardous wastes is expected to be generated from these two regions, also in foreseeable future. The project is also investigating the possible generation of hazardous wastes from other sectors such as oil and gas sector, mining industry, healthcare facilities, electronics and electrical equipment consumption, ODS, POPs etc.

Materials and Methods

The survey in the private industries in Yangon and Mandalay regions and in state owned enterprises, involved qualitative data collection, and was carried out in the Myanmar language. The survey methodology consisted of face-to-face interviews. All answers and observations by the survey team were recorded immediately on the survey questionnaires. As not all industrial activities generate hazardous waste, only the relevant industrial activities will be given priority, e.g. galvanic industry, oil refineries, electronic industry, pulp and paper, textile, chlor-alkali, pesticides, iron and steel, dyes and pigments, paints and printing inks, cosmetics, metallurgical industry, tanneries and hospitals.

Establishing an inventory of current hazardous waste generation is an important milestone of hazardous waste management planning. It is the reference for the extrapolation of future hazardous waste generation and the subsequent determination of types, capacities and locations of disposal and recovery installations required in the future. Though a data accuracy of + 20% is sufficient for planning purposes, estimation of hazardous waste generation may become difficult subject to the availability of baseline data.

In principle hazardous waste generation can be assessed from direct data related to the waste streams, available from governmental sources; secondary data and/or conduction of own surveys. In order to get more reliable data it is recommended to always use more than only one method and to crosscheck the results against one another.

In order to initiate the fact-finding process for hazardous waste inventory, technical baseline and ongoing waste related projects, the Technical Task Force team has been established comprising of permanent members from SINTEF, its local consultants (EQM and EGUARD), ECD- Nay Pyi Taw, Regional ECD officials in Yangon and Mandalay, Regional DISI officials in Yangon and Mandalay, City Development Committees of Yangon and Mandalay.

The task force has been meeting regularly in order to establish solid guiding principles for selecting industries for survey; discuss findings and shortcomings/challenges/risks of the waste survey and make qualified recommendations for the master plan; and discuss on issues to be prioritised within an overall context of hazardous waste management goals. Many observers also attended the task force meetings from relevant projects, institutes and NGOs.

The following actions have been undertaken for conducting the survey:

1. Shortlisting of industry categories and sub-categories with potential to generate hazardous wastes- sub-categories selected out of more than 300 industry subcategories;
2. Preparing the list of all privately owned industries in Yangon and Mandalay against the shortlisted sub-categories with the help from industrial zone management committees, regional DISIs, ECD, regional ECDs and city development committees;
3. Shortlisting of industries for conducting surveys by making industry visits;
4. Developing the questionnaire with the help of JICA expert team and YCDC- common questionnaire (in English and Myanmar language) was used in Yangon and Mandalay by JICA expert team and SINTEF for the waste water and hazardous waste surveys respectively; separate questionnaire developed for surveying state owned enterprises;
5. SINTEF and its local consultants visited the selected industries in Yangon and Mandalay and to the state-owned enterprises; often with the officials of ECD, YCDC, MCDC and DISI;
6. The weighted average waste factor for a hazardous waste stream (for example Reject paints) generated from a sub-category of industry (for example Paints & Varnishes) was calculated by dividing the 'sum of that hazardous waste generated from the surveyed industries from that sub-category by the sum of workers working in the surveyed industries in that sub-category of industry'. The calculated waste factor is expressed as 'kg of waste per worker'.

7. The waste factor was multiplied with the total number of workers against that sub-category of industry in Yangon or Mandalay to estimate the total generation of that hazardous waste from that subcategory in Yangon or Mandalay. The data on number of workers against a sub-category of industry was collected from regional DISIs;
8. The hazardous waste generation from all sub-categories against a category of industry was added to estimate the hazardous waste generation from that category (for example, clothing, consumer goods etc.); tables on the hazardous waste generation in Yangon and Mandalay is presented in the next section.

Results

Major industries in Myanmar belongs to sectors such as food & beverages; wood and wood products; copper, tin, tungsten, iron; cement, construction materials; pharmaceuticals; fertilizer; oil and natural gas; garments, jade and other precious gems- contributing more than 20% of GDP. Nearly 90% of the 44 500 privately owned industries are small and medium scale; more than 60% of industries from food and beverages sector. The industries are organized in 24 major industrial zones (6 currently under development). There are three Special Economic Zones (SEZs) in Myanmar, currently in different stages of construction. Thilawa (outside Yangon) is the only SEZ to have made considerable progress.

As per the global review of solid waste management published by World Bank in 2012, urban Myanmar with a population of 12,8 million generated 5616 tonnes/day of solid wastes with the per capita waste generation of 0.44 kg/capita/day. At present, the solid waste generation is estimated to be over 7000 tonnes/day. By 2025, both the urban population and the rate of solid waste generation is expected to double and waste generation from urban Myanmar would reach about 21 012 tonnes/day with 0.85 kg/capita/day (Hoornweg and Tata, 2012).

The two major cities, i.e. Yangon and Mandalay generates 2700 tonnes/day and 1000 tonnes/day of solid wastes, respectively. The collection and disposal process is characterized by non-segregation of wastes, intermediate street-corner depots, informal recycling by rag pickers (at disposal site) and by waste handlers (during loading on to trucks), considerable manual handling and open dumping.

Table 1: Estimated generation of hazardous wastes in Yangon

Category	Subcategory	Wastes	Hazardous Waste Generation in tonnes/year
Food and Beverages	Alcohol, Cold storage	Used Engine oil	0,3
Clothing	Dyeing	Wastewater treatment Sludge, Used Engine oil	287,8
Household Appliances	Paints and Varnishes, Printing	Oil based solvent, Reject and expired paints, Tank Cleaning Thinner, Wastewater treatment Sludge, Used Engine oil, Contaminated Drum, Clothes/rags with Colour pigments, Plastic bags with pigment residues	435,4
Consumer Goods	Plastic Products, Fibre Products, Cosmetics, Cleaning Liquids, Mosquito Coil, Traditional Medicines	Waste residue containing ink, Used Engine oil, Contaminated Drum, Wastewater Treatment Sludge, Chemical deposits, Blood and clinical waste	62,5
Minerals and Metals	Metal Mills, Metal Foundry	Acid Residue, Used Engine oil, Paint Residue, Lead slag	1 105,3
Raw Materials	Fertilizers, Rubber	Contaminated Drums, Used engine Oil	54,7
Construction Materials	Steel	Used engine Oil	0,2
Electronic Appliances	Electronic Products, Lead Battery, Transformer	Used engine Oil, Lead rejects, Wastewater treatment sludge, Reject battery, Used Transformer Oil, Transformer Oil Sludge, Paint Residue	170,7
General Industry	Lubricants	Reject lubricants, Contaminated drums	1,8
Total			2 119
Generation per day			5,8

In the industrial zones in Yangon, 139 privately owned industries were surveyed from sub-categories such as Plastic products, Metal foundries, Rubber, Cosmetics, Paints, Paints/Varnishes, Paper, Fertilizers, Distillery, Lead acid battery etc. More than 80% of the industries surveyed are in the industrial zones of Hlaing Tharyar; Shwe Pyi Thar; South Dagon, Shwe Lin Pan, Dagon Seikkan and Maung Ta Kar. The estimated hazardous waste generation from Yangon is 2100 tonnes/year, majorly lead slag from battery recycling, sludge from waste wastewater treatment, used oil, ink/paint sludge, used solvents etc (refer to table 1). In addition, the major non-hazardous waste generated are metal slags from electric arc furnaces, ash from industrial boilers, general garbage, sand moulds used for metal fabrication etc.

Table 2: Estimated generation of hazardous wastes in Mandalay

Category	Subcategory	Wastes	Hazardous Waste Generation in tonnes/year
Clothing	Dyeing	Wastewater treatment sludge	89,7
Consumer Goods	Plastic Products, Cleaning Liquids	Waste residue containing ink, Used lubricants, Wastewater treatment sludge	1,8
Raw Materials	Tannery	Wastewater treatment sludge	23,0
Electronic Appliances	Electronic Products, Lead Battery	Varnish residue, Sludge from used acid, Mix of tar and zinc	6,8
Total			121
Generation per day			0,3

In the Pyi Gyi Dagon industrial zones and six townships in Mandalay city, 45 privately owned industries were surveyed from sub-categories such as Plastic products, Metal foundries, Tannery, Cleaning Liquid, Fertilizers, Mosquito coil, Lead acid battery, Tyres, Electronic products and Textile dyeing. The estimated hazardous waste generation from Mandalay is 120 tonnes/year, majorly wastewater treatment sludge from textile dyeing and tanneries (refer to table 2). In addition, the major non-hazardous waste generated are metal slags from electric arc furnaces, ash from industrial boilers, general garbage, packaging wastes etc.

State owned chemical enterprises under Ministry of Industry includes textile industries, pharmaceuticals and foodstuff industries and paper and home utility industries. The state owned petrochemicals enterprises under Ministry of Energy and Electric Power (MoEE) includes petroleum refineries, fertilizer plats, CO_2 plant and bituminous plant. The data could be collected from 13 state owned enterprises; rest were shut down or non-operational at the time of the visit.

The estimated hazardous waste generation from state owned enterprises is 110 tonnes/year- 100 tonnes/year of wastewater treatment sludge from No. 4 fertilizer plant (Yangon region) and No. 8 textile factory (Mandalay region) is dumped onsite; and 10 tonnes/year of dead animal bodies and body parts from No. 1 pharmaceutical factory (Yangon region) in incinerated captively. The three oil refineries of Myanmar Petrochemical Enterprises under MoEE generate 125 000 tonnes/year of skimmed oil which is sold to recyclers. In Thanlyin refinery, approximately 600-700 tonnes of oil sludge is stored and awaits disposal.

Considering that the industrial development and hazardous waste generation will grow at the same rate as the GDP as projected in the National Comprehensive Development Plan 2030 published by Ministry of Planning and Finance, the hazardous waste generation in the year 2030 will become 1,8 times from current generation in low growth scenario (if GDP grows at the rate of 4,7% during 2017-2030), 2.5 times from current generation in medium growth scenario (if GDP grows at the rate of 7,2 % during 2017-2030) and 3.1 times from current generation in high growth scenario (if GDP grows at the rate of 9,1% during 2017-2030).

Wastes from healthcare facilities

Myanmar has 975 government hospitals and 182 private hospitals and several small clinics, dispensaries and health centres with 49 500 available beds and treatting more than 7 million outpatients each year (CSO, 2017). Wastes produced in health facilities include sharps (syringes, disposable scalpels, blades etc.), non-sharps (swabs, bandages, disposable medical devices etc.), blood and anatomic waste (blood bags, diagnostic samples, body parts etc.), chemicals (solvents, disinfectants etc.), pharmaceuticals, and may be infectious, toxic or radioactive.

Table 3: Generation and management of healthcare wastes in Yangon and Mandalay

Type of Waste	Generation	Packaging	Disposal
Infectious wastes	Yangon: 1,5 tonnes/day Mandalay: 0,8 tonnes/day	In yellow bags	Yangon: Burnt in cemetery; Mandalay: Open burning in dumping site and body parts are burnt in cemetery (incinerator in South Mandalay is under maintenance and will be ready by early 2018).
Sharps and syringes	Yangon: 0.7 tonnes/day Mandalay: 0,4 tonnes/day	In red bags	Yangon: Sub-merged/ buried; Mandalay: Open burning and residue buried under soil (incinerator in South Mandalay is under maintenance and will be ready by early 2018).
General non-hazardous wastes	70-80% of total wastes	In blue/green or black bags	Dumped
Expired medicines	No estimates		Yangon: Sub-merged/ buried; Mandalay: Open burning and residue buried under soil; Disposal conducted in association with Food and Drug Administration

As per the WHO estimates, of the total amount of waste generated by health-care activities, about 85% is general, non-hazardous waste and the remaining 15% is considered hazardous

material that may be infectious, toxic or radioactive. The broad estimates of healthcare waste generation suggests that Myanmar would generate approximately 10 tonnes/day of hazardous infectious and sharps wastes majorly from Yangon, Mandalay and Nay Pyi Taw. Total generation of healthcare waste including non-hazardous general waste is expected to be approximately 30 tonnes/day in Myanmar. These figures are being validated by way of representative surveys and/or interviews with the officials from public health division of MoHS, healthcare facilities and city development committees. Ministry of Health and Sports is currently implementing a project with the World Bank to improve the service expansion and quality of health services (including healthcare waste management) in Myanmar.

Wastes from oil and gas sector

Drilled cuttings removed from the wellbore and spent drilling fluids are typically the largest waste streams, by volume and weight, generated during oil and gas drilling activities. The drill cuttings are separated from drilling fluids by shale shakers, centrifuge etc. The volume of cuttings produced will depend on the depth of the well and the diameter of the hole sections drilled. The hazardous wastes generated from gas pipeline, block valves and metering stations are 40-50 tonnes/year of pigging sludge from pipe cleaning, oil filters, used oil/lubricant, batteries, expired or off specification chemicals (used for corrosion inhibition) and rags contaminated with oil. In addition, another 250-300 tonnes/year of non-hazardous waste is generated consisting of paper, plastics, household wastes etc.

Waste electrical and electronic equipment (WEEE)

In Myanmar, there is no data on quantity of generation of e-waste, a term used to cover items of all types of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste without the intention of re-use. As per the STEP (saving the e-waste problem) initiative of UNU, in 2014 the estimated generation of e-waste was 29 000 tonnes.

Mercury and cyanide containing tailings from gold mining

Myanmar's gold production is 54 400 Toy Oz or 1692 kg per year (CSO, 2016). There are more than 300 occurrences of primary and placer gold bearing deposits weighing > 60 million tonnes. The gold mining industry is dumping an estimated 16.3 kilograms (36 pounds) of mercury – a dangerous and toxic mineral – into Myanmar’s waterways per day, from where it is entering the food supply and potentially poisoning the population, a former government official has warned (Kyaw, 2014). Few companies still uses the cyanide leaching process. The companies generate equivalent quantity of tailings as ores processed containing mercury or cyanide depending on the gold separation reagent used in the process. This is because gold concentration in ore is very small and ranges from 3 to 5 ppm- 3 to 5 grams of gold for every tonne of ore.

Ozone depleting substances (ODS) in Myanmar

Currently there are no estimates of ODS stockpiles in Myanmr; Hydro-chloro-fluoro-carbon or HCFC consumption in Myanmar was calculated as 77.80 tonnes (equivalent to 4.30 Ozone Depleting Potential or ODP tonnes). Under unconstrained conditions or business as usual consumption of HCFCs can increase to as high as 37.3 ODP tonnes (UNEP, 2012). MONREC is currently the national body responsible for the implementation of the Montreal Protocol in the

country and the ministry works in consultation with National Ozone Unit (NOU) at operational level.

Persistent organic pollutants or POPs

Hazardous stockpiles of obsolete POPs pesticides are expected to be located at different locations in the country. Myanmar has ratified to the Stockholm Convention on 19th April 2004 (status: accession) and the Convention has entered in to force in Myanmar on 18th July 2004. On 30th June 2016, Myanmar's industry ministry (MoI) has published lists of prohibited and restricted chemicals that cannot be manufactured, imported, used or sold in the country which also included mercury; sodium cyanide; and hydro-chloro-fluoro-carbon (HCFC). National Implementation Plan or NIP on POPs is being prepared now with support from UNIDO and is expected to be ready by March 2018. NIP will include inventories of POPs.

Discussion

The inventory was conducted at an early stage prior to the development of appropriate legislation or the adoption of a national definition for hazardous waste. Therefore, data were collected for all kinds of wastes; certain assumptions were made for classifying the wastes in to hazardous wastes and non-hazardous wastes. There is a need to re-validate the waste classification in discussion with ECD based on Myanmar's Draft/final hazardous waste classification.

The hazardous waste generation in Yangon and Mandalay is lesser than expected. This is because most of the waste streams (including hazardous waste) are not controlled and assumed to be discharged into drains, sewers, surface waters or soil are not controlled; only little hazardous waste is accumulated at the site making the estimation of waste generation a difficult exercise. The other challenges and limitations of the survey is elaborated in next section.

SMEs were not familiar with the hazardous wastes definition and classification. This was overcome partly by explaining what was expected out of them ; several capacity building workshops were conducted on hazardous waste characterization, classification and environmentally sound management practices with participation from industries, industry associations, industrial zone management committees, city development committees, academia and relevant ministries in association with ECD-MONREC and NEA.

In many cases, the hazardousness assumption should be verified by testing. Such detailed analysis is usually not possible in inventories based on qualitative surveys and data analyses. This means that the inventory findings may overestimate (or underestimate) the true amount of hazardous wastes. Some industries were also reluctant to share information either because the data is confidential (raw materials, process etc) or that they fear regulatory actions.

The estimates of hazardous waste generation for Myanmar could not be projected based on the findings from Yangon and Mandalay. This is because, regional DISIs under Ministry of Industry provides industrial data based on 13 broad categories and more than 300 sub-categories whereas Central Statistical Organisation under Ministry of Planning and Finance is reporting national statistics of industrial production based on Myanmar Standard Industry Classification.

In a more advanced stage when a national system is in place with detailed HW legislation, licensing and enforcement it is the self-monitoring and compliance monitoring system that

produces data for annual HW inventories. These second generation inventories could be updated annually or compiled to answer specific questions.

Current waste management practices

In Myanmar, industrial solid waste are handled and treated together with municipal solid waste. More often than not, mixed waste contains hazardous components, which can be harmful to the environment and most of all to the workers and scavengers at the landfills and the residents in the vicinity. There is an absence of systematic database and the exact rates of industrial waste generation is not known.

Myanmar does not have sanitary landfills. The remaining life of all the dumping sites visited in Mandalay (2 dumpsites one each in North and South Mandalay) and Yangon (2 permanent dumpsites and 4 temporary dumpsites) was found to be between 5 to 10 years. Most dump sites face challenges in terms of operations and management.

Less than 1% of waste is incinerated (hospital wastes and expired medicines) but there are no technical standards for incineration. Mixed industrial hazardous waste is buried in to the ground or contained in concrete chambers. The healthcare wastes and industrial waste is majorly collected and transported by the City Development Committees on call barring the large hospitals and special clinics. The willingness to pay for waste services is currently low.

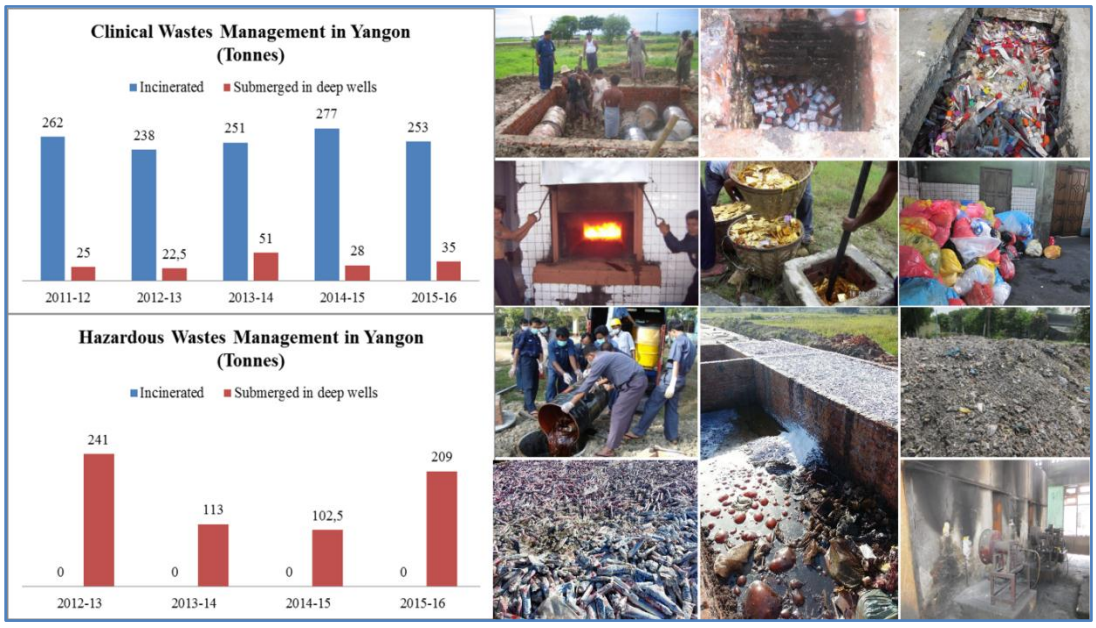

Figure 1: Quantity of clinical and hazardous waste disposed in Yangon by incineration and submerged in deep wells (Source of data: YCDC)

Figure 2: Waste management facilities in Golden Dowa inside Thilawa SEZ

Golden Dowa Ecosystems Private Limited, inside the Thilawa SEZ has secured landfills for hazardous and non-hazardous wastes, covered sorting/stabilization shed, handling plant for oil & gas wastes, wastewater and leachate treatment plant and laboratory. The facility was commissioned in 2016 with an investment of 36 million USD and is currently accepting wastes from industries in Thilawa SEZ, oil and gas companies, chemical industries from Yangon, gas turbine plant (Used glycol and used chemicals), and beverages manufacturer (ETP sludge).

Myanmar has commissioned its first waste-to-energy (WtE) power generation plant with an investment of 16 million USD at an YCDC owned site near Mingalardon temporary waste dumping site which will produce 700 kilowatt (kw) by using 60 tonne garbage per day. A medical incinerator is proposed to be set up in North Mandalay with aid from South Korea with capacity of disposing 10 tonnes per day; the project is being discussed and may only be initiated in 2-3 years.

Management of wastes from oil and gas sector

Petronas and PTTEP has started sending the pigging sludge to Golden Dowa in Thilawa SEZ. Pigging sludge from Petronas has traces of mercury which after cleaning by Daya- Malaysiais is sent to Golden Dowa. Pigging sludge from Total is currently stored in tanks inside its Kanbauk base. All the pipeline centres have small scale incinerators and captive landfills. The combustible non-hazardous wastes are incinerated; food waste is composted or sent to pig farms; and plastics and paper wastes are recycled. Incineration ash, contaminated soil and flue dust from bag filters are sent to captive landfills. In Total, fluorescent bulbs are also put in lined landfill.

Management of e-wastes

In Myanmar, until now, e-waste has almost been a non-issue because of the culture of repairing rather than replacing electronic devices. There is an active informal sector in these countries with an established network for collection of end-of-life products and their recycling, particularly

repair, refurbishment and parts harvesting. As per the SINTEF interviews with the shop owners in 28th Street of Yangon downtown, the used or discarded electronic items are managed by unlicensed recycling practices from the backyard which comprise of the following steps:

- Dismantling into various parts (metal frames, power supplies, circuit boards, plastics), often by hand, but increasingly by automated shredding equipment;
- Open burning for segregating organic and inorganic compounds (for example, burning cables to recover copper);
- Using acids to recover gold, silver, palladium and copper, largely from printed circuit boards.

Environmental impacts of current waste management practices

In Myanmar, industrial solid waste are handled and treated together with municipal solid waste. All wastes is dumped in the open without any leachate treatment or landfill gas control, creating serious concerns of ground water contamination, emissions due to open burning and communicable diseases; in addition to bad aesthetics and bad odour. Mixed wastes can contain toxic wastes, e.g. solvents, heavy metals, and other chemicals. In Yangon, it is estimated that for every tonne of municipal solid waste dumped, 480 Kg of CO_2 equivalent is released as direct emissions (IGES, 2016).

Treatment and disposal of healthcare waste may pose immediate health risks indirectly through the release of pathogens and toxic pollutants into the environment. Incineration of waste has been widely practised, but inadequate incineration or the incineration of unsuitable materials results in the release of pollutants into the air and of ash residue. In developing countries, a trade-off has to be made between direct health risks from absence of waste management leading to reuse of syringes, and indirect health risks created by environmental pollution (e.g. by production of dioxins from inadequate incineration).

Chemical use is a major health and environmental concern in the context of Myanmar where the institutional capacity and the general awareness of chemical risks and the impact of toxic emissions is low. The contamination of potable water sources and the food chain with pesticides is one of the main concerns.

Informal processing of e-waste is not only inefficient but may cause serious health and pollution problems as the scrap components may contain contaminants such as lead, cadmium, beryllium, or brominated flame retardants. Lack of awareness (about segregation, management and adverse impacts); lack of incentives (unwillingness to pay for waste management services); lack of convenience; absence of suitable sites; and weak governance and enforcement are cited as main reasons for unsound management of e-wastes in developing countries.

There are numerous areas in Myanmar that are suspected of having mercury contamination as a result of gold mining activity. Suspected mercury-impacted areas include communities along the Ayeyarwaddy river, Chindwin river, and Tanintharyi river, which are the largest rivers of the country. Artisanal small gold mining (ASGM) is currently the largest source of mercury pollution in the world, accounting for more than 35% of total anthropogenic emissions (UNEP, 2013). In a study, covering 25 countries, levels of more than 1 ppm of the mercury was found in hair samples of women in Myanmar involved in ASGM (Bell et al, 2017).

Conclusion

Although the management of solid waste and healthcare wastes in the three cities and in industrial estates are conducted by City Development Committees in Nay Pyi Taw, Yangon and Mandalay, limited and insufficient facilities and lack of technologies result in serious pollution and health problems from solid wastes and wastewater. Many outstanding initiatives, projects and treatment options are already in place or under development in Myanmar. However, to meet rapidly increasing demand there is an need to identify new landfill sites, to upgrade the technical infrastructure, to improve waste management practice (especially for hazardous & industrial wastes) and to increase the treatment capacity, first of all in Yangon and Mandalay.

There are a number of factors why countries do not have sanitary landfills. These are: lack of finance for infrastructure; land acquisition issues; "not-in-my-backyard" or NIMBY syndrome; low willingness of citizens to pay for municipal services leading to insufficient fund for proper treatment and disposal; unqualified or non-licensed operators; an unsuitable soil profile if the site happens to be near the urban centre etc.

As per the waste management hierarchy, waste prevention (including reuse) and waste recovery are the preferred options in comparison to disposal. Recovery can be differentiated into recycling (material recovery), energy recovery and other waste treatment options. Recycling makes use of the material value embedded in waste whereas energy recovery utilizes the calorific value. When selecting between material- and energy recovery for a given waste type (provided both options are possible), priority should be given to the option that has less negative environmental impacts. Sometimes both the energy and the material will be utilised simultaneously, e.g. when co-processing of alternative fuels and raw materials in the cement industry.

There seems to be a large untapped potential for industrial symbiosis, resource efficiency and circular economy; i.e. for recycling, recovery and integrated treatment options. Some of the probable hazardous waste streams requiring attention in Myanmar are infectious healthcare wastes, e-wastes, old stockpiles of PCBs, expired pesticides, wastes from oil & gas drilling and refining, mercury and cyanide containing gold mine tailings, sludge from effluent treatment and slags/ashes from furnaces and boilers. There is a need to raise awareness among public and an urgent need to build professional capacity on all technical aspects of environmentally sound management of hazardous waste.

For Myanmar, one of the major policy priority should be to develop legislations and regulations that reflect best practices for environment conservation, followed by enhancing institutional capacity and effective enforcement. In Myanmar there was no national law protecting the environment until 2012. The Environment Conservation Law (ECL) was enacted in March 2012. The Environmental Conservation Rules enacting the ECL was approved in 2014. There were, however, several sectoral laws, related to environmental protection. Myanmar is a signatory of Basel and Stockholm Conventions. ECD is currently drafting the list of hazardous wastes and regulations for import and export of hazardous wastes, with guidance from Norwegian Environmental Agency.

SINTEF will be preparing the master plan for hazardous waste management in Myanmar by conducting technical baseline and feasibility studies, in order to obtain data that reflects the current waste situation and expected future generation of hazardous wastes, sufficiently to be used as an input for description of a conceptual hazardous waste treatment and disposal system for priority waste streams. Regulatory and institutional framework for sustainable waste

management and implementation of Basel Convention will be proposed by Norwegian Environment Agency and will be a part of the master plan.

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