Faecal Sludge Management - Way of Transition/Transformation

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Abstract

In most countries of the Global South on-site sanitation systems – septic tanks and pit latrines – are the most common. As mostly existing facilities are in a inadequate state and a working faecal sludge management is missing, hygienic and environmental problems become obvious.
Transition from the discharge oriented wastewater paradigm to a new wastewater recycling will only take place, if changes are necessary anyway. This is obviously the case in many countries of the Global South. The current lack of sewers with connection to a central wastewater treatment plant and the condition of the sewerage system existing could be a starting point for the change of the sanitation system – from a system based on dilution to a system of (re)use based on separation of different wastewater streams (greywater, blackwater, faecal sludge, pre-treated wastewater etc.).
The transition process is by far not a linear completely foreseeable process. The transition path will be influenced by stakeholder priorities and the availability of money. For the transition timeline economical possibilities are crucial to the success of the transition.
The transition process should be designed as a continuous improvement process.

Problem Statement

In Bangladesh, like in many other countries, on-site sanitation systems – septic tanks and pit latrines – are the most common.
To run those facilities properly, faecal sludge management services are needed (Fig.1).
As mostly existing facilities are in a inadequate state (not water tide, too small, not accessible, overflowing toilets – particularly in the rainy season,…) and a working faecal sludge management (FSM) is missing, hygienic and environmental problems become obvious. In many developing countries FSM services are often unavailable or if they are available they are often informal, unregulated, unhygienic and unsafe (Strande et al., 2014).Existing practices cannot handle the fast growing urban population and offer no reliable solutions for rural areas.
Most sanitation service providers are individuals operating informally, known as sweepers (URL1).
A common practice in both low- and middle/high-income areas is to connect pour-flush toilets directly to drains (improper sewers, creeks, rivers), without any onsite storage or treatment.

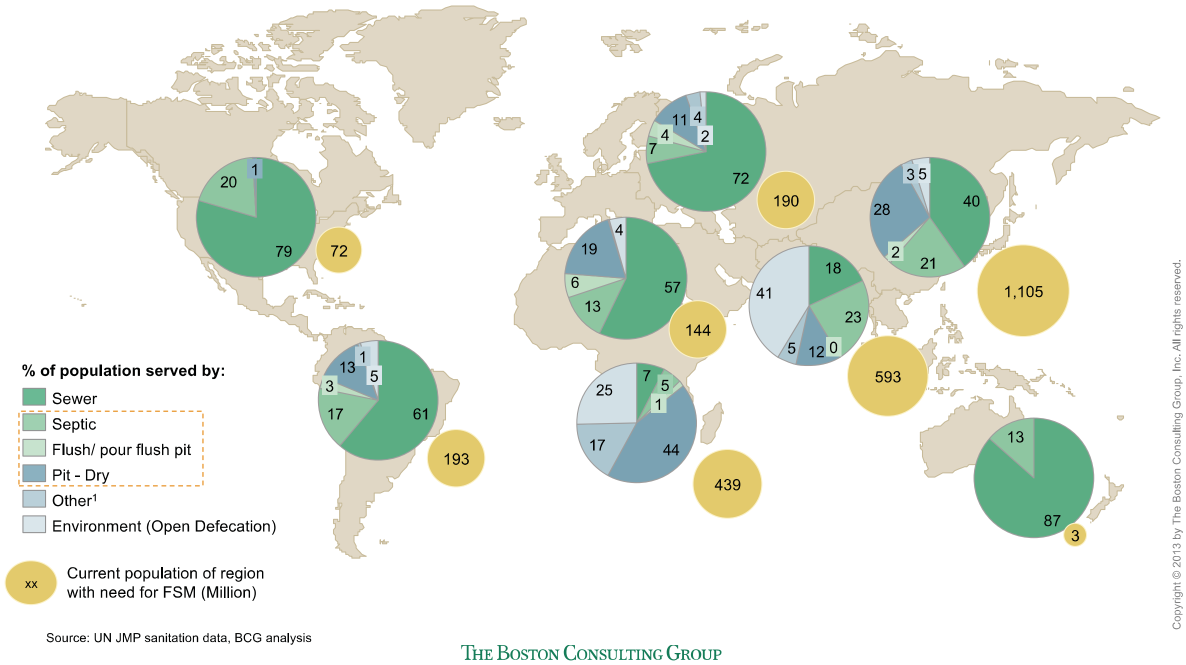

Fig.1: Percentage of people served by different types of sanitation systems (Strande et al.(eds.), 2014)

On the other hand the centralized system, which is based on gravity sewerage, is described as state of the art in common standard text books (Imhoff et al. 2017, Metclaf and Eddy, 2013). This is only a solution if a properly working wastewater treatment plant is the barrier between sewerage and receiving water.
Some 80% of Dhaka's rapidly growing population – around 12 million people – lacks access to sewered toilets and is therefore dependent on on-site sanitation. 99% of the faecal sludge produced by Dhaka's 16 million residents returns to the environment untreated, causing widespread public health issues (URL2).
Khulna, the third largest city in Bangladesh, has a population of 1.5 million people, similar to Barcelona or Munich, has no public sewage system. But donor-funded projects have focused on sewerage improvements in urban areas on the model of standards and knowledge described in the literature mentiond above.
There are manyarguments against construction of sewerage, which will be discussed in the transition chapter.

As the central sewer based systems have been developed as emergency systems against epidemics during industrialisation of the Global North, they had to be improved in itself because of long depreciation periods of the technical infrastructure and the associatedsunk cost.Actually new alternative sanitation systems (NASS) are launched, which follow a new paradigm of reuse, central and decentralized(Larsen and Gujer, 1996; Londong, 2013; DWA, 2014).

The research initiative WINGS (eawag) strives to develop novel non-grid-connected water and sanitation systems that can function as comparable alternatives to network-based systems.
In an international workshop we agreed amongst other thingsto "recognizethe diversity of technical and social urban water management systems available and the possible varietyof decentralization degrees (centralized, semi-centralized,

decentralized, hybrid) that can constitute locally appropriate urban water management systems“. Urban water managementcomprise different sectors, such as water supply, stormwater, wastewater, energy, solid waste, transport and leverage synergies between the different sectors and systems. (eawag, 2018)

The last two examples show, that new approaches are on their way and should be considered in a transition process for urban water management.

On-Site Technologies and Definitions

Faecal sludge is a mixture of human excreta, water and solid wastes (e.g. toilet paper or other anal cleansing materials, menstrual hygiene materials) that are disposed in pits, tanks or vaults of onsite sanitation systems.

Faecal sludgethat is removed from septic tanks is called **seepage (sepage).**

Seepage is the partially digested faecal solids that accumulate in **septic tanks**. Faecal sludge from pit latrines may have a lower water content compared to seepage and may contain more solid waste.

“Septic tank sludge" is partially treated sludge.

If the septic tank has an overflow (regular or due to operational problems) **wastewater** will be discharged to the environment.
Septic tanks are receiving blackwater from flush toilets, as well as greywater. This means that seepage only contains the kind of solid waste that can be flushed, such as toilet paper.

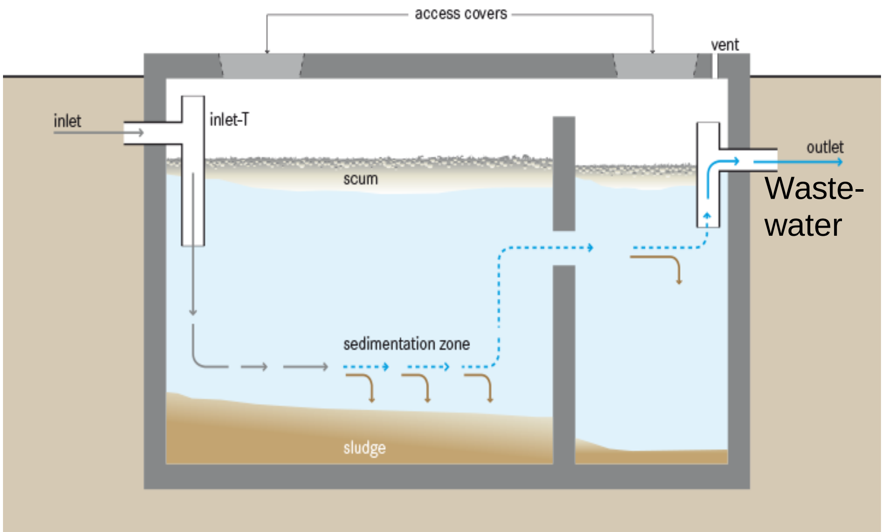

Fig. 2: Septic tank(Tilley et al., 2014)

The **Imhoff tank** is a primary treatment technology for raw wastewater, designed for solid-liquid separation and digestion of the settled sludge (Fig. 3). The sludge has to be removed from the tank.

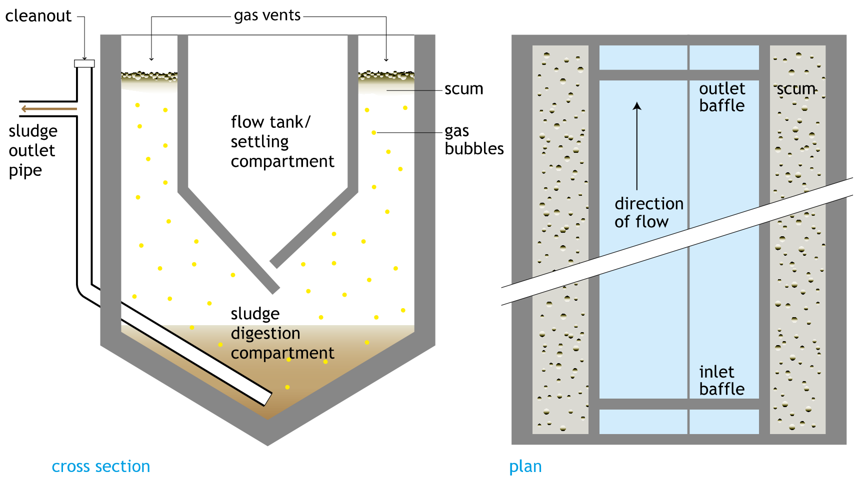

Fig 3: Imhoff-Tank(Tilley et al., 2014)

With **pit latrines** human urine and faeces are collected in a hole in the ground.Pit latrines functioning without water are called **dry toilets**.If they are used with a small amount of water and have a water seal, they are named **pour-flush pit latrines**.

New Technical Solutions

In this chapter some hints are given on new developments for dealing with faecal sludge, seepage and wastewater.

First of all it has to be stated, that a proper management is a precondition for all technical solutions. This will not be the focus of this paper.
There are many technical options and operational possibilities. The open access IWA-book "Faecal Sludge Management" (Strande et al. (eds.), 2014) is highly recommended to learn about a best practice systems approach for implementation and operation. It is stated that faecal sludge management requires an integrated systems level approach, incorporating technology, management and planning.

Combining the management of septic seepage with organic waste, including municipal bio-solids and agricultural residues could increase the economy.
Besides a proper management of seepage, it also envisages to find, rethink and evaluate possibilities to utilize the mentioned material flows in relation to energy, material and nutrient recovery.

An example of a novel on-site reuse system is theBlue Diversion Toilet of eawag (Larsen et al., 2015, URL5).The Blue Diversion Toilet is a solution for densely populated urban slum areas.
The toilet has a flush function (for the front part), a washbasin for hand washing, and a showerhead for personal hygiene (for anal cleansing and menstrual hygiene). The water for these functions is water that is recycled and treated on-site in the back wall of the Blue Diversion Toilet. The toilet has been successfully tested in the field in Uganda (2013) and Kenya (2014).A toilet with urine and faeces treatment on-site with on-site fertilizer production is under development (URL5).
The Blue Diversion Toilet was developed in conjunction with a business model, which covers all activities along the sanitation value chain.
The needs are similar to the combined faecalsludge management concept mentioned above and might be conducted together in a transition phase (see next chapter).

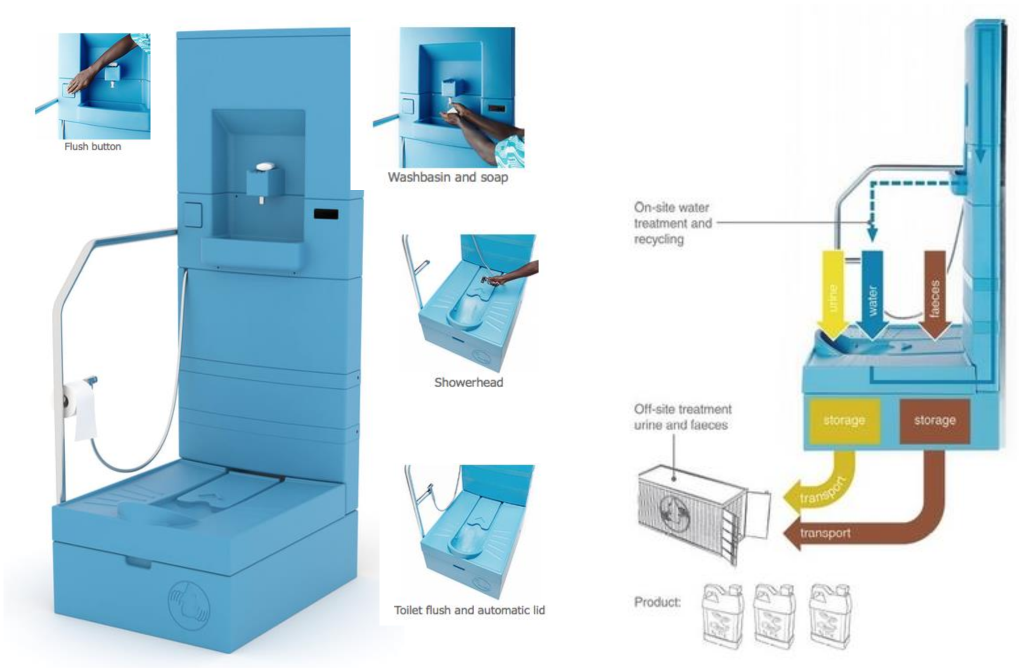

Fig. 4: Blue diversion toilet, developed by eawag (URL5)

One example of a technical solution is the biological treatment using aquatic plants in existing drainage.
Houtan Park in Shanghai, Chinademonstrates a living system, where ecological infrastructure can provide multiple services for society and nature and new ecological water treatment and flood control methods (URL3).

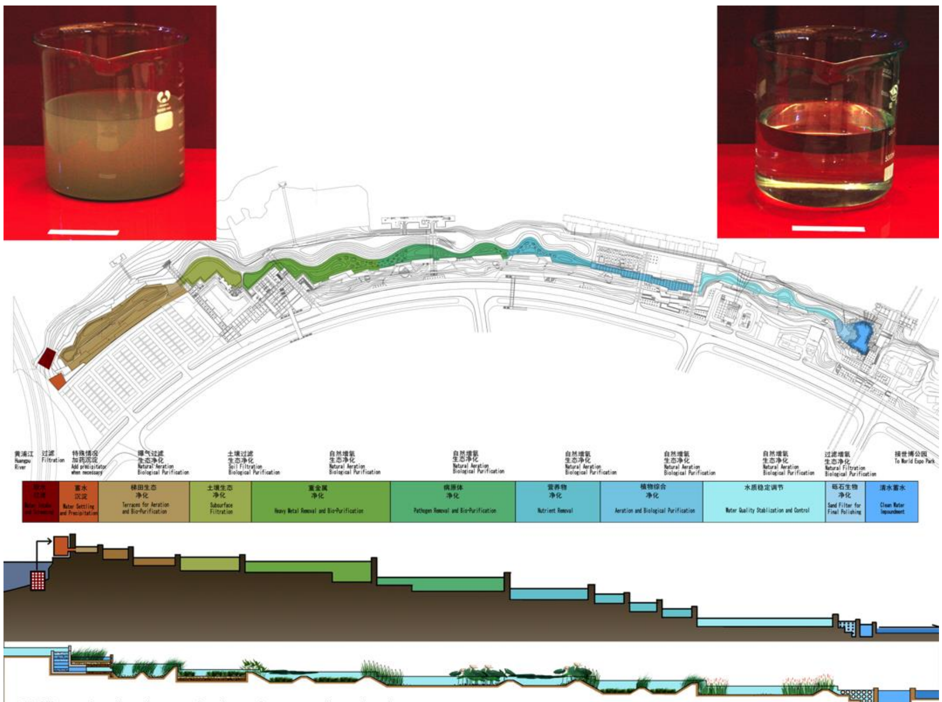
02 The water cleaning mechanism of man-made wetland

Fig. 5: Water cleaning mechanism, Houtan Park in Shanghai, China (URL3, https://www.asla.org/2010awards/images/largescale/006_02.jpg)

Houtan Park has been built on a brownfield of a former industrial site. The park's linear constructed wetland reclaimed industrial structures and materials. It is 1.7

kilometres long and 5–30 meters wide. The aim is to treat polluted river water and recover the degraded waterfront in an aesthetically pleasing way.Cascades and terraces are used to oxygenate the nutrient rich water, remove and retain nutrients and reduce suspended sediments. Different species of wetland plants were used in the cascades.

Fig. 6: Houtan Park in Shanghai, China before and after (URL4, https://www.landscapeperformance.org/case-study-briefs/shanghai-houtan-park)

Fig. 7: TiO_2-coated expanded glass bead granules

The natural system's performance could be supported by photo-catalyticreaction on a titanium dioxide catalyst coated partials (Fig.7) under natural UV light (sunlight), floating on the water of the drains. In this way, viruses, bacteria, medicines, antibiotics and organic pollutants can be oxidized. The technology has been developed and tested at in Weimar. In our experiments, diesel fuel served as substitute for non-polar pollutants such as petrol-derived hydrocarbons. The application of this simple low-tech method does not needs trained personnel (Jautzus et al, 2018).

Transition

The majority of empirical studies on sustainability transitions have been conducted in Europe (Coenen et al., 2012 citied in Chang et al. 2017). The application of these transition concepts in Bangladeshand comparable countries is more than questionable. While focusing on environmental sustainability they are ignoring regional social-political context like ill-functioning institutions, market imperfection, social exclusion, inequity etc..
Therefore business models must be integrated in a transition strategynecessarily. Business models should be based on the material flow.The flow of money must be embedded.

For an successful transition/transformation process it is necessary to

1. know from where you start
2. have an idea what you aim at
3. to identify possible intermediate goals, priorities and measures on the time line and
4. work in a loop in a continuous improvement process (Fig. 8)

From where you start
First of all the starting position has to be defined answering the following questions:

What is the current sanitation situation? Which health and environmental problems are obvious?
How are the topography and hydro-geological conditions, taking high water table and flood-prone areas into account?
Which technical solutions are available today?
How is the quality of the different sludge and wastewater streams? Which variations according concentration and quantity should be expected?
Which boundary conditions need to be fulfilled to implement a technical solution successfully? Who are relevant stakeholders?
Sustainable environmental sanitation may be achieved or enhanced only by applying appropriate financial incentives and sanctions.

Have an idea what you aim at
The most essential needs are hygienic sanitation solutions and acceptable environmental conditions (like water and soil quality).
Taking into account the increased prices for resources like energy, fertilizer and using the political will to improve the sanitation situation, the wastewater sector shows a high potential towards the integration of resource orientated NASS and resultantly a sustainability transition of the wastewater sector.
Addressing the challenges associated with the current sanitation sector the most important question is, how the service could be managed sustainably (Gambrill 2018).

Identification of possible intermediate goals, priorities and measures on the time line
The transition process is by far not a linear completely foreseeable process. The transition path will be influenced by stakeholder priorities and the availability of money.For the transition timeline economical possibilities are crucial to the success of the transition.

The “Compendium of Sanitation Systems and Technologies” (Tilley et al., 2014) is highly recommended for the identification of technical and institutional measures. Mansour et al.(2017) provide additional advices.
A lack of space in densely populated slum areas often makes the provision of individual household toilets impossible. Then communal toilets need to be considered. Several households must use the same facility, not on a pay-per-use basis. Pay- per-use public toilet facilities can be implemented in busy areas(wsup, 2017).
Next to the onsite facilities itself, transport and treatment options adaptable to high-density areas must be taken into account in the planning of sanitation services. The availability of land (mostly privately owned in slums) for sanitation improvements (e.g. constructing decentralised treatment plants) is a further challenge(wsup, 2017).

Proper FSM is in need to prevent sludge and wastewater discharges directly into the drains.

It has to be questioned, whether

- onsite sanitation technologies are acceptable solutions also for densely populated areas,
- how the technical solutions do need to be adapted,
- which technical solutions have the potential to gain profit (consider resource recovery),
- which stakeholders have to be involved to operate the technical solutions and
- it is possible to frog leap intermediate measures (like a central sewerage), if not necessary.

Improvement and enhancement of existing infrastructure should be preferred over the installation of completely new systems. There are a lot of arguments against a construction of sewerage.Missing or not functioning treatment plants will not improve the environmental situation. The construction of a sewer network and treatment plants and their operation are expensive (1 €/person and day in Germany).
Rapid rates of urbanisation have created areas of very high population density, presenting a challenge for the construction of networked solutions, transfer stations and treatment plants.

Transition from the discharge oriented wastewater paradigm to a new wastewater recycling will only take place, if changes are necessary anyway. This is obviously the case in many countries of the Global South. The current lack of sewers with connection to a central wastewater treatment plant and the condition of the sewerage system existing could be a starting point for the change of the sanitation system – from a system based on dilution to a system of (re)use based on separation of different wastewater streams (greywater, blackwater, faecal sludge, pre-treated wastewater etc.).

The term sanitation system includes a sequence of technologies and services (i.e. collection, containment, transport, transformation, utilization or disposal) (Tilley et al. 2014). The resource-orientation itself is based on a separate collection, treatment and reuse of material flows. Integrating these systems into local conditions such as existing infrastructure, markets etc. is essentiall to successfully build, operate, maintain and control the system. Due to social, political and organizational aspects the implementation of resource-orientated sanitation is supposed to be more complex compared to conventional, discharge oriented systems. Thus, beside technical solutions a transition strategy including business models is needed to guarantee sustainable systems.

Continuous improvement process
The transition process should be designed as a continuous improvement process (Fig. 8).

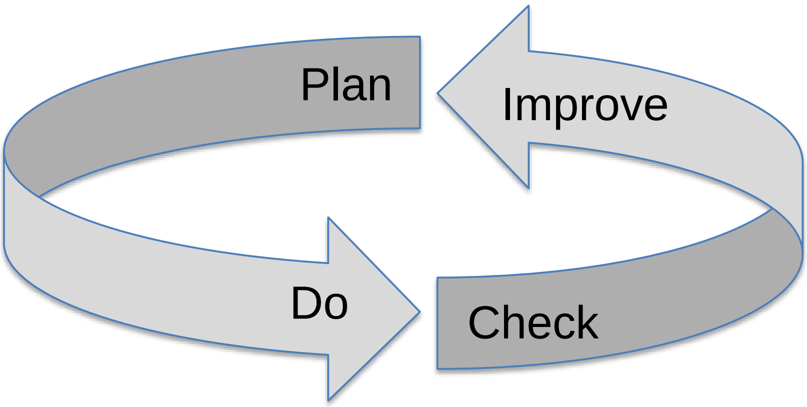

Fig. 8: Continuous improvement process

An initially defined objective may change over time and the selected measures may not proof most suitable. The formulation of measurable goals and efficiencies helps to check the results of intermediate transition steps and improve the plan.

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Identification and Estimation of Mercury Emissions in Bangladesh: towards Development of a National Mercury Profile for Ratification of the Minamata Convention

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Keywords: *mercury inventory, Minamata Convention, mercury waste, mercury-added products*

Bangladesh is a deltaic plain crisscrossed by many rivers and remains extremely vulnerable to mercury contamination from uncontrolled dumping of mercury along with medical, industrial, electronic wastes into the waters and soil, uncontrolled coal burning in brick kilns, fish-dependent protein diet of the population, cement and paint industries, and through the use of mercury-added products as well as medical applications of mercury (dental amalgam). Bangladesh has signed The Minamata Convention on Mercury on 10 October, 2013 and is actively approaching towards ratification of the convention. Bangladesh Government will aim at protecting human health and environment by adopting measures for reduction of mercury emissions and releases. The goal of that treaty, and thus of Bangladesh as a Party to it, is to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds.

In Bangladesh, major mercury emission sources are use and disposal of products with mercury content, production of mercury added products, open fire waste burning, informal dumping of general waste, production of oil and natural gas, coal combustion etc. Bangladesh does not manufacture consumer products (except light, paint and cosmetic products) but relies on imports from other countries. The imported items include many of the mercury-added products. Besides, dental amalgam remains the preferred restorative material in dental practice.

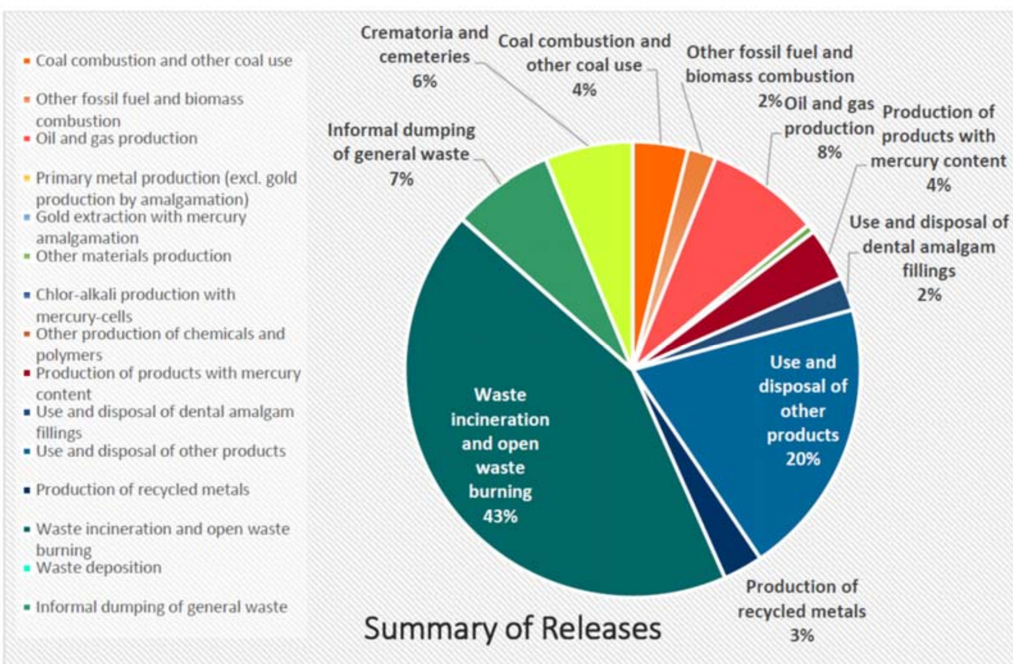

Figure 1: Summary of mercury releases in Bangladesh

The national mercury inventory has been prepared as a key activity towards the ratification of the Minamata Convention. This inventory analysis has been performed using Inventory Toolkit provided by UNITAR.

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According to the inventory, The total mercury releases are 32,660 kg per year and the major significant anthropogenic sources of mercury are:
1. waste incineration and open waste burning: 44.00 per cent (14,323 kg Hg/y),
2. use and disposal of other products: 20.00 per cent (6,564 kg Hg/y),
3. oil and gas production: 8.00 per cent (2,675 kg Hg/y),
4. informal dumping of general waste: 7.00 per cent (2,397 kg Hg/y),
5. crematoria and cemeteries: 6.00 per cent (2,066 kg Hg/y),
6. coal combustion and other coal use: 2.00 per cent (781 kg Hg/y), and
7. production of products with mercury contents (thermometers, paints, cosmetics, light, battery): 4.00 per cent (1,258 kg Hg/y).

Regarding existing policy and legislations, there are regulations on environment conservation, waste management, air pollutant action plan etc. as well as institutions for testing and maintaining standards of products, yet more specific and detailed policies need to be developed and institutional strengthening needs to be done to address the potential threat released by mercury to the environment and human health. The existing rules does not state clearly the management strategy for mercury substances or does not directly limit uses of mercury in the processes.

A series of actions has been proposed to meet the obligations provided by Minamata Convention in order to mitigate mercury emission from anthropogenic activities. Major actions are listed in the following:

1. Incorporate obligations of the Minamata Convention into existing national legislation through amendments and establish a monitoring cell at national level for mercury management in line with the provisions of Minamata Convention.
2. Develop guidelines for environmentally safe operation of incinerators, hazardous waste recycling and re-refining
3. Prevent the use of dental amalgam, particularly for populations at risk (young children and pregnant women) while minimize the use of amalgam for other population groups
4. Separation, collection and environmentally-sound storage of mercury-added products such as batteries, lamps, medical equipment, and adoption of guidelines for safe use and disposal
5. Increase enforcement activities (penalty, seizure of products, etc) against unsafe skin cream and beauty products manufacturing
6. Eliminate open burning of solid and hazardous waste in dump sites, prevent incineration of mercury waste in healthcare facilities, segregating mercury waste from medical waste and sending them to specialized facilities as well as formulate and endorse solid waste management rules.

High percentage of mercury release from waste management sector points out the need for constructing centralized facility for safe storage and management of hazardous waste. Open burning of solid and hazardous waste in dump sites should be eliminated and solid waste management rules should be implemented and endorsed as soon as possible.