The Bantan landfill – Landfill operation, and leachate treatment

Integrated Resource Management in Asian Cities
the Urban NEXUS
(Water / Energy / Food Security / Land Use)

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1. INTRODUCTION AND BASICS

Urban nexus

The urban nexus approach aims at integrated planning and management processes which can contribute substantially to the sustainability of cities and their regions. The Economic and Social Commission for Asia and the Pacific (ESCAP) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH are implementing the project “Integrated resource management in Asian Cities: the urban nexus”, financed by the German Federal Ministry for Economic Cooperation and Development (BMZ). The project supports ten cities in six countries, by providing technical advice to municipal administrations for the design, planning and, where possible, implementation of practical nexus initiatives. Experiences gained at the local level will feed into regional dialogue, in support of scaling-up the urban nexus approach.

2. LANDFILL SITE ASSESSMENT

2.1. LANDFILL DATA

A site visit was performed on 08 June 2015. Information on the waste inputs, engineering details, and environmental conditions of the site are raised during this visit. Additional site Information by the municipality or other instances were not provided. A questionnaire was not filled.

Data collected from other parties during the visit has been verified or information adjusted based on the results of site specific observations made during the visit.

The following paragraphs highlight the data obtained and analyzed for Bantan Landfill.

2.1.1. CATCHMENT AREA

Chiang Mai Province is about 685 km from Bangkok in the Mae Ping River basin and is on average at 300 m elevation. Surrounded by the mountain ranges of the Thai highlands, it covers an area of approximately 20,107 km². The mountains of the Daen Lao Range at the north end of the province, the Thanon Thong Chai Range stretching in a north-south direction, and the Khun Tan Range in the east of the province are covered by rain forest. The capital of Chiang Mai Province, Chiang Mai, is the largest and most culturally significant city in Northern Thailand. It is 700 km north of Bangkok and is situated amongst the highest mountains in the country. The city sits astride the Mae Ping River, a major tributary of the Chao Phraya River.

While officially the city (thesaban nakhon) of Chiang Mai only covers most parts of the Mueang Chiang Mai district with a population of 160,000, the city's sprawl extends into several neighboring districts. The Chiang Mai Metropolitan Area has a population of nearly one million people, more than half the total of Chiang Mai Province (source: Wikipedia.com).
2.1.2. SITE LOCATION

The Bantan landfill is located 115 km south west of Chiang Mai following Route 1012 on a 320 ha property in private possession. Approx. 30 – 40 ha of this property are used for the landfill. The site is situated in a plane near the Bantan Village, Hod District. No larger urban settlements or industrial facilities are located near the landfill site. Small creeks and ponds are to be found around.

Figure 1: Satellite-view of Bantan landfill (source: Bing.maps), purple: old landfill area, yellow: new landfill area, red: leachate treatment area

2.1.3. SITE HISTORY

The landfill was set up in October 1998. In 2009 a power plant operated from landfill gas with a generation capacity of 1 MWh was installed. In 2012, the power plant was expanded and an additional 1 MWh of electricity was generated. Together with the power plant retrofit a facility for drying crops by using thermal energy from the electricity generation process was built with a max. capacity of 30 tons of crops per day.
2.2. WASTE COMPOSITION

The waste generated in Chiang Mai is highly biodegradable. It is mainly composed of an organic fraction with high moisture content. Food waste, plastic/foam, paper, metal, and glass are the main components of the waste. The composition of MSW in Chiang Mai is shown in Figure 3.

Chiang Mai MSW composition

2.3. WASTE MANAGEMENT AND LANDFILL OPERATION

Apart from Chiang Mai MSW (Municipal Sewage Waste) also waste from other municipalities is discharged at Bantan landfill. The actual total daily waste input is 600 tons (300 of Chiang Mai, 300
of others). The MSW is transported by special trucks that are possessed by the landfilling company. The waste is collected locally (the frequency of the MSW collection in Chiang Mai was not reported) and transported to local “transfer stations” on which it gets pre-sorted and loaded to the landfill trucks. These trucks than are transporting the waste to the “remote” landfill (115 km, 2.5 hours driving “one way”). Around 20 waste trucks loads per day are transported.

No weighbridge is located at the site entrance, so the waste trucks entering the landfill without determination of the transported waste weights. Scavenging activities at the site were observed.

2.4. LANDFILL HEALTH AND SAFETY

During the site visit different issues that may collide with general Health and Safety (HS) rules were observed like:

- Scavenging around working machinery
- Inadequate personal protection equipment
- Non-compliance with ATEX-rules within the biogas installations
- Missing air quality monitoring
- Missing leachate accruing quantity and quality monitoring

Due to the importance and the complexity of this topic it was not possible to address all HS issues during the site visit. We therefore strongly recommend an additional HS-survey of the site.

2.5. LANDFILL FIRES

No landfill fires or signs of subsurface combustion were either reported or observed during the site visit.

2.6. SITE CONSTRUCTION

The general site conditions and engineering design features were examined during the site visit. Waste inflow and composition data were discussed, and operational practices observed. The subsequent sections describe the pertinent features observed at the site.

2.6.1. GENERAL OBSERVATIONS

The design of the site is a mound fill bounded mainly by groves. No industry or major agricultural used land is located near the landfill site. The next settlement is about 2.5 km north of the landfill site. The landfill is located in a hilly area, north east of the landfill, the land starts to become mountainous.
The landfill comprises two waste mound deposit areas (see Figure 1). In Figure 1 the purple bordered area (approx. 75 ha) shows the old landfill area that was in use from 1998 – 2014. The yellow bordered area shows the actual tipping field (approx. 24 ha) that is operated since 2015.

The active tipping area seems to be well managed. No larger areas of the tipping cell were uncovered. Scavaging took place directly at the tipping area but nowhere else at the landfill.

The landfill cell in operation is equipped with a bottom liner with geo-membrane. It was reported that the cells are equipped with a leachate collection system as well.

The closed cell was reportedly lined with a geo-synthetic lining system. Advanced containment design features like interlocking sheet piles to retain waste placed along the perimeter of the landfill cells are not installed. The closed cells were covered with soil as interim cover material. LFG discharge pipes were installed to degas the closed cells. A basic gas collection system ensures that the gas is routed to a booster station prior to pretreatment and utilization (additional information see chapter 2.7.1).
Information on the leachate management infrastructure is to be found in chapter 2.7.2 No guard or any fencing of the ground or the tipping area was observed.

2.6.2. ENVIRONMENTAL DATA

According to available meteorological data (World Weather Information Service at http://worldweather.wmo.int/en/home.html), the average annual rainfall at Chiang Mai is 93.9 mm, and the temperature ranges from 28.3 to 36.1°C (see Figure 6). The site is therefore categorized as extremely wet and hot, potentially enhancing the rate of waste degradation and leachate generation.

Figure 6: Chiang Mai Climatological Information (taken from World Weather Information Service)
2.6.3. WASTE DEPTH

No data were provided. Site observations during the site visit are indicating a waste depth of approximately 24m in the closed cells.

2.6.4. WASTE PLACEMENT

As previously already mentioned, the waste delivering trucks were not weighed before the waste disposal at the active tipping area. Waste is brought to the site in own trucks that are foil covered to prevent odour emissions during transportation. Additionally the trucks are equipped with a tank to prevent leakages of leachate from the transported waste.

The trucks are offloaded in the tipping area. The waste is spread and pushed to the edge of the leading waste slope by track mounted dozers (see Figure 7). The open tipping area is kept small and the disposed waste is covered with soil on regular basis to stabilize the landfill and to avoid emissions during operation of an active landfill cell.

![Figure 7: Offloading a waste truck in the tipping area](image)

It was observed that there are additional trucks available for cover soil transport as well as different excavators and loaders. Dedicated compactors were not seen. All machinery was observed in fair conditions. Track mounted excavators were in operation at the time of the site visit, but no compactors. The waste density was not reported.

2.6.5. SLUDGE PLACEMENT

No sludge placement, past or present, was reported by the landfill management, or observed during the site visit.
2.6.6. BASE LINING

It was reported that the whole landfill cells were constructed with a geo-composite base and site-slope lining (1,5 mm HDPE). Before lining, the ground was compacted and graded. To seal the single HDPE sheets they were welded to each other. A compacted layer fine soil was applied above the liner to prevent tearing from waste disposal operation and the leachate collection pipes were relocated at the basis of the landfill cells.

During the site visit the existence of the liner was determined and the preparation of a new tipping area with the liner was observed (see Figure 8)

![Figure 8: Preparation of the base lining for a new landfill cell](image)

2.6.7. CAPPING LAYER

The not operated / closed cells are covered with cohesive soil (60 cm). A membrane cover was neither observed, nor reported.

Compaction of the waste body appeared to be well performed due to no signs of differential settlement being observed during the site visit. Compaction and stability of the soil cover appeared to be o.k.

2.6.8. SURFACE WATER MANAGEMENT

No diversion channels were observed around the waste disposal areas to divert storm-water away from the waste mass. Rainwater and surface water may intrude into open cells. No runoff retention systems were observed. Precipitated water may seep into the soil. The soil itself seems to be highly water permeable.
2.7. GAS AND LEACHATE

2.7.1. GAS

Landfill gas is collected from the closed waste cells through numerous vent pipes (PCV with bamboo cover for mechanic protection). The vents are connected via a temporary very basic LFG collection system (see Figure 5) with booster stations.

Two booster stations are existing, sucking the LFG from the closed cells and routing it to desulphurization reactors. The desulphurization of the biogas is done biologically in packed columns. The biodesulphurization does not seem to be in full operation, as only half of the columns are pipe-connected. Additionally a commonly used nutrient dosing was missing as well as an oxygen control and air dosing system.

Balloon gas holders are used as intermediate LFG storage before it gets routed via a gas dryer to the co-generation systems. Two Jenbacher Type 3 1MW_el CHPs are operated to convert the LFG into heat and power.

The max permanently generated biogas amount that is required for a 24/7 operation of both CHPs with 100% output is approx. 800 - 1000 m³/h with a methane content > 45%. It was reported, that the CHP systems are actually suffering from low methane content of the collected LFG. Whenever the LFG methane content underruns 40% Methane, the CHPs have to be stopped to avoid damage. The operator has to wait for LFG with more substantial methane content before getting back into operation. Unfortunately there are no intervention opportunities for improving the methane content than moving the gas collection system to other areas leading to extended down time periods.

We assume, that the very basic gas collection system and the missing top liner of the waste cells are responsible for the low methane content. In connection with the reported low LFG recovery efficiency of about 50%, it is likely, that ambient air could be sucked into the waste cells and the LFG collection system. This would lead to a dilution of the LFG by ambient air reducing the methane concentration in the gas. Additionally intruding air (Oxygen) could reduce or even stop the methane generating anaerobic activity in the waste cells.
2.7.2. LEACHATE

Leachate is the liquid produced by contamination of water within the landfill site by a wide range of solutes resulting from the disposal and decomposition of waste (including organic and inorganic components) in landfills. The water content results from drainage of moisture from the original waste, water resulting from degradation, and infiltration of surface water (rainfall). Leachate can be highly contaminated and usually has a very low concentration of dissolved oxygen.

![Bantan landfill leachate treatment system](source: Preliminary Feasibility Study of SSLTES, Thanomboon 2015)

It was reported, that a leachate drainage system consisting of drainage channels that divert the leachate collection pipes was built at the base of the landfill when preparing the lining and protection system of the bases of each landfill cell. Due to the moderately hilly terrain and the fact, that the disposal cells do not go very deep into the ground (rather a land-raise than a landfill) we assume that the leachate is sent by gravity through the drainage system to the leachate treatment system.

Originally the leachate treatment system consisted of an anaerobic pretreatment followed by an open pond (aerobic) system with consecutive evaporation lagoons (see Figure 10).
Anareobic system

Two different anaerobic leachate treatment systems are present. The originally installed UASB (Upflow Anaerobic Sludge Blanket) reactor is a high rate anaerobic system that requires particular pelletized biomass. Due to the special properties of this biomass, comparably high biomass concentrations are possible without the demand for additional biomass retention equipment. Although this reactor can handle very high pollution loads, a proper salt content in the wastewater that has to be treated is required. Leachate with its salts spectrum and hardening salts like Calcium and Magnesium in particular are leading to undesirable changes of the granular sludge properties (increase of specific gravity and size) which lead to permanent failure of UASB systems.

It was reported, that the Bantan landfill leachate is coming along with lots of hardness contained. This is because there is a limestone containing soil at the site. The lime of the soil gets dissolved by acetic leachate (young landfills tend to generate acetic leachate because of biological reactions taking place in the landfill body) and finally ends in the leachate treatment system.

In case of an UASB - system this lime could cause lots of trouble. Therefor the existing UASB system is not in operation after several attempts to keep it running. But the operation results had been very poor and so the operator of the landfill decided to decommission it.

To carry on anaerobic treatment without the demand for specific granulated biomass two anaerobic lagoons had been installed (see Figure 10 lower left side and Figure 12). The lagoons were built as lined flow through ponds without agitation and mixing. The ponds are covered with a balloon gas holder on the tops.
At the site visit both lagoons do not seem to be in good shape, one was not in operation at all (see Figure 12). The plant manager reported problems with the biological process. No stable biogas production could be established and precipitation, already known from the UASB system, was observed.

Aerobic system

The aerobic leachate treatment is built as passive open pond system. Mixing, agitation or aeration equipment is not installed. Originally this treatment was foreseen to cut down heavy Ammonia loads by oxidation after the COD (Chemical Oxygen Demand) of the leachate was eliminated in the previous anaerobic treatment.

We assume, that due to insufficient COD elimination in the upfront anaerobic step and due to missing agitation and aeration the degradation of organic compounds or Nitrogen in this system is very poor and evaporation effects are used in this system to reduce the leachate volume.

Evaporation lagoons

The final leachate treatment is done by evaporation lagoons. The purpose of the lagoons is to reduce the final leachate amount by evaporating the water. This process requires high surface areas as well as a warm (hot/sunny) and ideally dry climate. Therefore the space requirements of such systems are increased (see Figure 10). The Bantan landfill evaporation lagoons are very basic basins without any lining or ground protection. There is (so far) no installation/equipment to handle remaining concentrates after evaporation.

During the site visit it was observed, that the lagoons are not sealed and the leachate could seep through (see Figure 13). It is very likely, that the leachate stored in the evaporation lagoons could also intrude unhindered into the ground below the huge lagoon area. This situation could become delicate, as the site manager reported that the soil contains reasonable amounts of limestone, which is well known of not being dense for acetic liquors like leachates from landfilling.

The quality of the raw leachate as well as the treated leachate is not reviewed on the basis of regular analyses. The daily/monthly accruing quantities of leachate are not detected as well. We assume, that the evaporation process is minor effective for this area because of the humid climate (see Figure 6). During the wet season the precipitation water is diluting the leachate ever again and so a possibly observed pollution degradation is a consequence of intrusion and dilution.

We cannot state, that the existing leachate treatment system is suited to retain the polluted leachate or its pollution at the leachate site. It is likely, that leachate pollution gets transported by intrusion to the ground or by wash out with precipitation surface water during wet season. This situation is even worsened by the problems and malfunctions of the anaerobic and aerobic leachate treatment systems, which does not seem to cut down the pollution as they should and so the pollution (mainly COD, Nitrogen and heavy metals) get released to the environment.
Figure 13: Evaporation lagoon at Bantan landfill (top), with leachate seeping through the soil (mid and bottom)