# Catbalogan City, Philippines Open Dumpsite Leachate Transport

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***Abstract:*** Uncontrolled leachate produced from a poorly managed dumpsite poses several dangers such as contaminating water bodies including ground water. Catbalogan City, Philippines produces about 141 cu.m. of waste/day disposed in its current open dumpsite. This volume of waste may produce an average of about 2.53 cu.m/day peak discharge of leachate runoff as an effect of precepitation. With the dumpsite located at higher elevation, such runoff will eventually find its way in to the sea specifically during extreme precipitation. The leachate runoff is diluted with runoff from the watershed of the area. Water quality analysis from samples collected within the vicinity of the dumpsite up to nearby creek and the nearest bay on two different occasion are within permissible limits set by Department of Environment and Natural Resources and World Health Organization. This suggests an insignificant effect to the water bodies nearby. To validate the observations made in this study, a real-time monitoring on the water quality of runoff, groundwater as well as those in the nearby bays maybe performed.

**Keywords:** waste transport, waste disposal, waste treatment, harmful algal bloom, HAB

## *1. Introduction*

Waste is a consequence of development. The growth rate of a population, degree of industrialization and other factors influence the waste generation. Ways of disposing of this trash are also attributed to the income of a community. Ideally, countries with higher income can provide efficient services and facilities to accommodate such waste generation (Hoornweg & Bhada-Tata, 2012).

Dumping on open land areas has been a common way of disposing waste especially on countries with lower middle income. There are about 42 countries in the world which belong to this class and uses open dumpsites as facilities in disposing of waste (Hoornweg & Bhada-Tata, 2012).

In the Philippines, the solid waste problem is most severe in urban areas particularly in Metro Manila, where population rate and consumption is at its highest, some of which are made with raw materials that are toxic and non-biodegradable (Magalang, 2014). Disposal of wastes in open pits is the cheapest and easiest waste disposal making it the widely used method of disposal mode; a choice for the majority (UNEP, 2005).

However, open dumpsites have a great impact on the environment and could cause harmful effects to humans. People residing near these sites are exposed to diseases which are sometimes spread by vermin and other disease-carrying organisms feeding-in on this area. Contaminations in these areas are also high in which hazardous chemicals could end up in the soil or bodies of water, affecting all ecosystems in the process. Water trickles from waste, such as leachate could enter water surfaces and if not controlled may add up to the growth of algae which causes algal bloom on bays and other water bodies (Sankoh, et.al., 2013). Even landfill in 38 of 50 biggest in the sites in the world also poses a threat to marine and coastal pollution (ISWA, 2016).

Waste management in cities with developing economies and in transition experience have exhausted waste collection services, inadequately managed and uncontrolled dumpsites and the problems are worsening (Hyman, 2013). Problems with governance also complicate the situation. Waste management, in countries and cities, is an ongoing challenge and struggle due to weak institutions, constant under-resourcing and rapid urbanization (ibid). All of these challenges along with the lack of understanding of different factors that contribute to the hierarchy of waste management affect the treatment of waste (Ogawa, nd).

Waste disposal problems are very common to most Local Government Units (LGUs) in the Philippines. In 2001, the Philippines enacted the Republic Act 9003 or the Ecological Solid Waste Management Law. The law requires that each LGU shall prepare, submit and implement a plan for the safe and sanitary management of solid waste generated in areas under its geographic and political coverage (Congress of the Philippines, 2000). Some of the requirement of the law was to develop a 10 Year Solid Waste Management Plan which includes among many others is the eventual closure of open dumpsite and the establishment of landfills. Since 2001, very few were able to comply with the basic requirement of the law. From 2010 to 2015, only 122 plans have been approved (NSWMC, 2015). To date, there are only a little more than 100 LGUs with landfill out of 1634 or about six percent of LGUs in the Philippines. In the Eastern Visayas Region, only Burauen, Ormoc and Calbayog City out of 143 or about two percent of LGUs have an approved sanitary landfill (NSWMC, 2015; DILG, 2016).

Catbalogan City was able to comply with the ten-year SWMP requirement of the law and has already a designated approved site for its landfill. To date, it still uses its open dumpsite receiving about 77.24 tons of waste daily (Moya, 2013). This dumpsite has been alleged by nearby LGU that its leachate flows into the nearby bay which results in the occurrence of harmful algal bloom (HAB) in the area, causing paralytic shellfish poisoning (Abrematea, 2014). However, there was no direct link that has ever been established in regards to this link according to the Catbalogan City government (CLGU Catbalogan, 2014).

## *2. Objectives*

This paper is an initial assessment of the feasibility of dumpsite leachate flowing into the sea. Specifically, it aims to;

2.1 Describe the Catbalogan City Open Dumpsite
2.2 Estimate the volume of leachate produced
2.3 Determine the leachate transport/destination

## *3. Methodology*

*3.1 Research Design*: The study uses mixed design methods. It considered field and laboratory experiments and descriptive designs.

*3.2 Research Environment*: The study area is the Catbalogan City open dumpsite located at Barangay New Mahayag and its nearby community within four km radius. The dumpsite's peak elevation is approximately 6.9 m above sea level covering a total of about one hectare. Alongside the dumpsite is covered by trees and shrubs including croplands. There is a creek flowing into an estuary and eventually the Irong-irong bay.

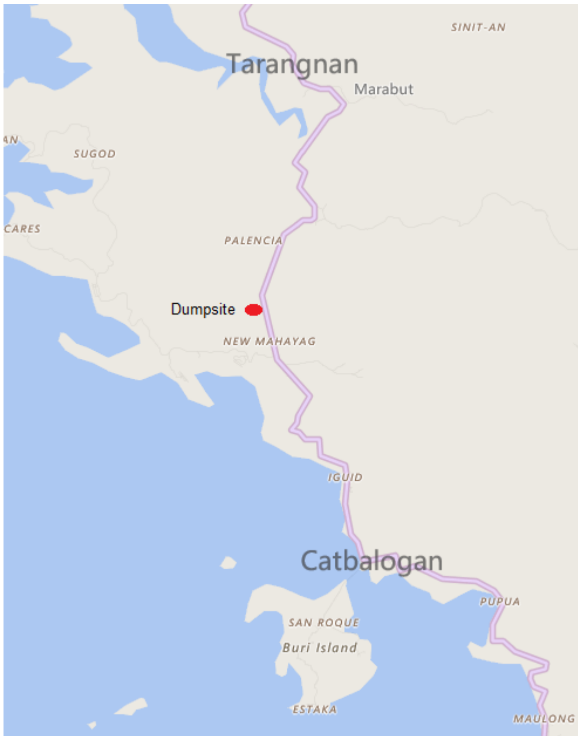


Figure 1. Study Environment

*3.3 Research Instruments*: The instruments used include theodolite for the topographic survey, a 1 x 1 x 1m container box for waste characterization, weighing scale, permeability apparatus and other soil property determination tools/equipment. Camera, checklists and data sheets for recording purposes were also used. Digital and printed maps from NAMRIA, Google Earth and Bing Maps specifically within the disposal site were also utilized. A three-scaled-dimensional (3D) model was developed based on the topographic maps. The 3D model was used in observing water (mimicking leachate) flow from the dumpsite to the creek and the nearby body of water.

The 3D model represents the land area between 11°53’16”N – 124°48’44” and down to 11°51’59”N – 124°50"37"E made of concrete and scaled approximately 1:4500. The flow of water (leachate) was observed using a colored water with similar specific gravity (1.21) to the leachate. The water circulation due to wind was simulated using a fan positioned to the recorded prevailing wind according to the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) records from 2011-2015.

*3.4 Research Procedure*: The study started with profiling the disposal sites using secondary data as the take-off point. Following the ocular inspection of the site and the nearby community, a plan of action was formulated including soil and water sampling and on-site waste characterization.

Five soil samples were extracted at least up to one meter from the surface for the soil permeability test. Waste characterization from five randomly selected areas was conducted, and three water samples were grabbed for water quality testing. Soil analysis including determination of leachate physical characteristics was conducted at the Samar State University – Soils and Materials Testing Laboratory (SSU-SMTL) and water samples were sent to Department of Science and Technology (DOST) – Regional Standards and Testing Laboratory. Previous tests results performed by the DENR were also used as a reference in this study.

*Data Analysis*: Data produced from various laboratory and field tests were used to estimate other parameters. Data were presented in terms of mean and percentages. Formulas used in the estimations are presented in the results section.

### *4. Results and Discussion*

Catbalogan City is comprised of 57 Barangays (Villages) with a population of 103,879 people (PSA, 2015) producing 77.24 tons of waste daily. Most of these waste end up in the open dumpsite while about 25% goes to the sea (Orale, 2009).

*Geophysical Characteristics of Dumpsite*. The dumpsite as shown in figure 2 is situated 6.9m above sea-level, and its topography influences the movement of surface runoff ending up to the nearby bay. Its exact location is at 11$^{o}$ 51' 11.33" N – 124$^{o}$ 49' 28.81" E. The dumpsite is approximately 14 km away from the city proper and covers approximately one hectare and is surrounded by vegetation such as trees, shrubs, and grasses.

The permeability of the soil in the area ranges from 0.000595 to 0.00817 cm/s or an average of 0.00504 cm/s. At a water temperature of 20$^{o}$C, the effective permeability is estimated at 0.00448 cm/sec enough for the leachate to seep into the soil. This, however, does not take into the effects of having a huge volume of plastics which may prevent some leachate from penetrating into the ground.

Infiltration rate is relatively high at an average of 0.00489 cm/sec with a runoff potential of low.

*Precipitation, infiltration, and runoff*. Catbalogan is located in a Type IV climate which means its precipitation is evenly distributed all throughout the year. More than half of the months from 2010 to 2014 are above the 30-year monthly average with December 2014 registering a total of about 1140mm of rain, 72% higher than normal (Orale, 2015). The 30-year average precipitation ranges from as low as 160mm in April to 370mm in November. According to world weather online, 295 of 365 days or 81% are rainy days from March 2015 to March 2016. Using rational equation method (Thompson, 2006) with rational coefficient of 0.1 to 0.3 for unimproved areas, average precipitation of 310 mm/year, soil permeability of 0.00489 cm/sec will result in an about 0.84 to 2.53 cum/day peak discharge of runoff. Shown in figure 4 is an example of runoff water estimated to be flowing from the dumpsite to nearby waterways considering 2015 rains on a monthly basis which may eventually exit to the sea or percolates to the ground. The sea is about 1.06 km from the dumpsite.

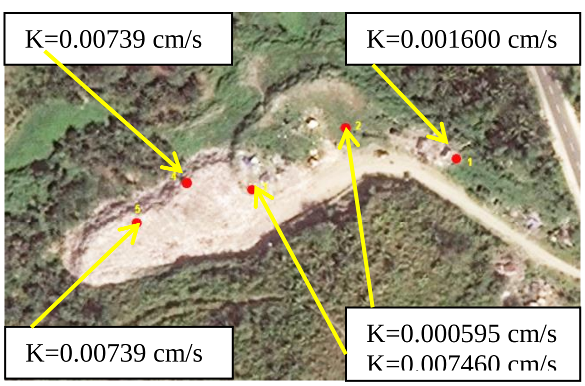


Figure 2. Soil permeability at the dumpsite

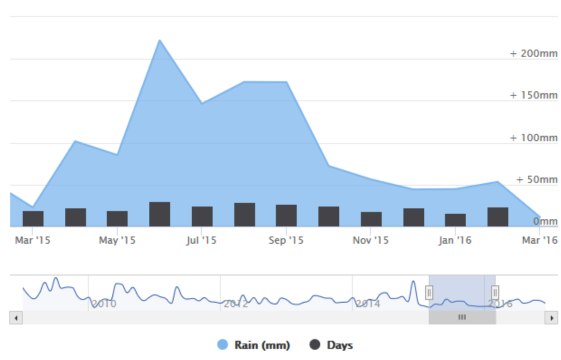


Figure 3. Rainfall Amount (mm) and Rainy Days (March 2015-March 2016)

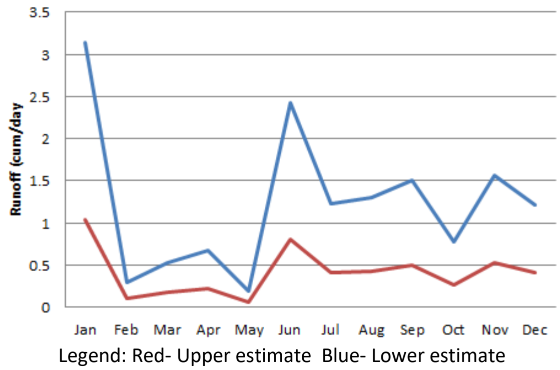


Figure 4. Runoff estimates from the dumpsite (2015 precipitation data)

The most likely path of the runoff is illustrated in figure 6 shown in pink dashed line drawn based on the contour of the area. The said runoff movement may occur during days with massive precipitation (example: December 2014 rains)


Source of contour map: www.openstreetmap.org

Figure 6. Most likely route of leachate runoff during heavy rains

*Leachate properties*. The computed specific gravity of collected leachate in the study site is about 1.21, with phosphate at 0.58 mg/l. Other properties were not determined.

*Volume and Type of Waste Disposed*. Table 1 shows the amount of waste generated per capita per day based on published literature. An estimated volume of about 419,882 cu.m. of waste have been disposed since the dumpsite establishment in 2004 to the year 2015.

The 131 cu.m. of waste is composed of 61.5% organic matter based on saples collected n-site. This organic matter when deteriorates mixes with the rainwater and became a major component of the leachate. Aside from this, it also has large amounts of inorganic contaminants (Kettunen, 1998) such as metals and some hazardous chemicals. Of the non-organic wastes, about 25 kg/capita/day of metal cans are collected by waste pickers. Cardboard/other papers, plastic bottles, and glass bottles constitute about 20, 10 and 5kg/capita/day is segregated by waste pickers and sold at nearby junkshops.

*Water Characteristics in Observation Stations*. Table 2 shows the chemical concentrations present in the water sampled in the study area. As shown, the concentration levels of nitrates, phosphate, and lead in the test sites are below the permissible level based on World Health Organization (WHO) and the Department of Natural Resources (DENR) standards. The results, however, do not mean that there is no contamination. Samples were collected during dry days where creek is almost dry. Runoff towards the sea is only probable during heavy rains. Furthermore, the sea has the high assimilative capacity to handle such runoff. The said probability needs further

**Table 1**. Estimated volume of waste in Catbalogan City Dumpsite

| Year | Population | | ± % p.a.[3] | Daily waste produced (kg/capita/day) [4] | Equivalent truck volume (cu.m./day) [5] | Volume of waste disposed (cu.m.) [6] |
|---|---|---|---|---|---|---|
| | Total[1] | Served by dump trucks[2] | | | | |
| 2004 | 88,781 | 66,559 | + 1.34% | 0.52 (Chandrappa et.al, 2012) | 87 | 31,764 |
| 2005 | 89,970 | 67,451 | | | 88 | 32,190 |
| 2006 | 91,175 | 68,354 | | | 89 | 32,621 |
| 2007 | 92,454 | 69,313 | | | 91 | 33,078 |
| 2008 | 93,068 | 70,248 | + 0.67% | | 92 | 33,525 |
| 2009 | 93,687 | 70,716 | | | 92 | 33,748 |
| 2010 | 94,317 | 71,191 | | 0.41 (Orale, 2011) | 73 | 26,788 |
| 2011 | 96,138 | 73,057 | + 1.93% | | 75 | 27,490 |
| 2012 | 97,995 | 74,468 | | | 77 | 28,021 |
| 2013 | 99,887 | 75,906 | | 0.66 (Moya, 2013) | 126 | 45,977 |
| 2014 | 101,817 | 77,372 | | | 128 | 46,866 |
| 2015 | 103,879 | 78,939 | | | 131 | 47,815 |
| | | | | Total Volume of Waste Disposed (cu.m.) | | 419,882 |

[1]Based on 2000, 2007, 2010 and 2015 census of population. Interim years are estimates.
[2]Population of mainland barangays with wastes collected and disposed at Catbalogan open dumpsite
[3]Per annum growth rate (PSA, 2007, 2010, 2015)
[4]Based on estimates as published. Orale(2011) and Moya(2013) were for Catbalogan City
[5]Equivalent truck load volume = $\frac{population\ x\ daily\ produced\ x\ average\ total\ volume/day}{2015\ population\ x\ daily\ waste\ produced}$
[6]Estimated volume of waste produced

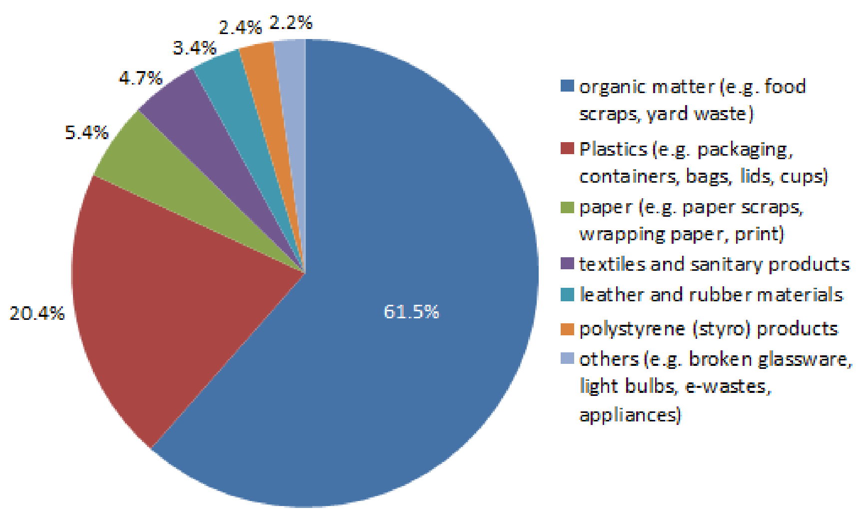


Figure 3. Dumpsite Waste Characterization

investigation and is not covered in this study.

Table 2 shows that the seawater sampled by the DENR-EMB which is about 19.9, 10.8, 14.3 and 1.7 km from the dumpsite contain very little traces of nitrate, phosphate, and lead; all of which are within the permissible limits set by DENR and WHO. The water samples gathered on September 13, 2016, were about 1m, 1km and 3.3km from the dumpsite have traces

**Table 2**. Water quality parameters of samples obtained in the vicinity

| Sample Location | Type of Sample | Distance from dumpsite (km) | Parameters | | |
|---|---|---|---|---|---|
| | | | Nitrate (mg/L) | Phosphate (mg/L) | Lead (mg/L) |
| Poblacion, Tarangnan Samar | Seawater* | 19.9 | <0.01 | 0.12 | <0.027 |
| Brgy. Bahay, Tarangnan, Samar | Seawater* | 10.8 | <0.01 | 0.15 | <0.027 |
| Brgy. Gallego Tarangnan | Seawater* | 14.3 | <0.01 | 0.07 | <0.027 |
| Brgy Old Mahayag, Catbalogan City | Seawater* | 1.7 | <0.01 | 0.06 | <0.027 |
| New Mahayag, Catbalogan City (1) | Leachate | 0.01 | - | 0.58 | - |
| New Mahayag, Catbalogan City (2) | Creek water | 0.95 | - | 0.13 | - |
| Brgy. Tizon, Tarangnan, Samar | Brackish water | 3.3 | - | 0.10 | - |

Limits: DENR EMB (1990): Nitrate 10 mg/l Phosphate 0.1 mg/l Lead 0.05 mg/l
WHO (1991): Nitrate 20 mg/l Phosphate 5.0 mg/l Lead <1.0 mg/l
* sampled by DENR

**Table 3**. Percent of leachate transported

| Prevailing wind direction | Location | Percent of leachate distributed/transported* | | | |
|---|---|---|---|---|---|
| | | Trial 1 | Trial 2 | Trial 3 | Average |
| Northeast | Brgy. Palencia, Tarangnan | 50 | 50 | 38 | 46.0 |
| | Brgy. Tizon, Tarangnan | 25 | 25 | 23 | 24.3 |
| | Cambatutay Bay, Tarangnan | 75 | 75 | 63 | 71.0 |
| Southwest | Brgy. Palencia, Tarangnan | 3 | 5 | 65 | 24.3 |
| | Brgy. Tizon, Tarangnan | 5 | 2 | 29 | 12.0 |
| | Cambatutay Bay, Tarangnan | 88 | 84 | 72 | 81.3 |
| Southeast | Brgy. Palencia, Tarangnan | 12 | 27 | 53 | 30.7 |
| | Brgy. Tizon, Tarangnan | 8 | 5 | 4 | 5.7 |
| | Cambatutay Bay, Tarangnan | 80 | 85 | 74 | 79.7 |

**based on color chart estimation of concentration compared to color of water in the physical model*

but were below the permissible levels set by authorities. The said tests were limited to phosphate concentration only. There is a need to conduct water quality sampling more than once specially during occasions of high precipitation where leachate is expected to reach the sea. When at sea, the leachate may be distributed through the prevailing water current.

*Leachate Transport through a Physical Model*. Based on the physical model, the amount of leachate that has entered in the Bay will settle mostly to the area of Cambatutay Bay. Less affected are the waters nearby Brgy Tizon and Brgy Palencia. Except during northeast wind direction, the percent of leachate traveling to this site is less than 10%. The distribytion shown on table 3 is based on surface current due to prevailing wind. There are other factors affecting sea current such as the differences in the temperature of water column, coriolis forces from earth rotation, the position of landforms that interact with current, the density of water masses (NOAA) and many others.

The amount and concentration of leachate varies greatly on the intensity of rain. For January 2015 rains, runoff water containing leachate exiting the dumpsite is estimated to range from 3.14 to 1.04 cum/day during peak flow. Since runoff water from the rest of the watershed will mix with the runoff coming from the dumpsite results into a much lower concentration levels. The creek in the area is intermittent; has waters after a rain and dries up during sunny days. Most of the water from the dumpsite percolates to the ground and usually do not reach the sea.

## *5. Conclusion and Recommendation*

The topography allows runoff water from the dumpsite containing leachate to flow towards the sea. However such runoff have little traces of contaminants as it is diluted by runoff waters from the same watershed where the dumpsite is located. Any amount of leachate that enters into the sea settles mostly along Cambatutay Bay until it is carried by current other than that attributed to the wind.

For validation of findings of this research, a real-time monitoring of water movement and quality from the dumpsite towards the sea and concentration may be explored. The use of computer simulation on runoff flow and wastewater transport may be performed to estimate amount or concentration of leachate as it percolates into the ground and runoff the surface.

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