

ASSESSMENT OF GROUNDWATER AND LEACHATE QUALITY FROM BALAOAN SANITARY LANDFILL IN LA UNION, NORTHERN PHILIPPINES

Leonora E. Ngilangil

Professor, Don Mariano Marcos Memorial State University
Bacnotan, La Union, Philippines
Email: lengilangil@gmail.com

Abstract: Landfills are point sources of pollution. In this study, it seeks to assess the groundwater and leachate quality in Balaoan sanitary landfill using physico-chemical and biological characteristics and to compare the results to quality standards. Proper coordination with authorities, ocular visits and surveys and final evaluation on the study site were made to ascertain the presence of a leachate pond and deep/tube wells within or near the facility. Groundwater and leachate samples were collected through grab sampling during the months of February and April and sent for laboratory analyses. Except for the Total coliform and E.coli counts, the physico-chemical parameters of the groundwater samples such as pH, turbidity, total dissolved solids, and nitrate were found to conform to the Philippine National Standards for Drinking Water (PNSDW). Leachate water samples in terms of Chemical oxygen demand were found to conform to the regulatory limit while toxic metals such as cadmium, chromium, copper, lead and mercury showed very low concentration based on DAO 35, series of 1990 class C waters.

Keywords: Groundwater, Landfill, Leachate, Physico-chemical, Waste Disposal

Introduction

Solid waste management remained to be a serious problem in the country. Despite the enactment of Republic Act 9003 known as the Ecological Solid Waste Management Act, nothing has improved. The volume of wastes being generated particularly in the urban centres tends to increase with increased population growth. According to a 2012 World Bank report, South Asian and Pacific countries will have to cope with a 150% increase in household waste by 2025 (<http://www.theguardian.com/world/2013/jan/29/manila-philippines-recycling-payatas> accessed October, 15, 2015). Improper waste disposal is not only an eyesore but has serious environmental consequences to the soil, air, ground and surface waters and even to human health. Groundwater contamination may be the most serious problem caused by improper waste disposal because, as usually the case in the Philippines, dependence on groundwater for drinking purposes is very common. Sanitary landfills are the most widely utilized method for solid wastes disposal. In the Philippines, there are about 960 sanitary landfills and of these, there are 936 controlled and open dumps. Accordingly, sanitary landfills are waste disposal site designed, constructed, operated, and maintained in a manner that exerts engineering control over significant potential environmental impacts arising from the development and operation of the facility (RA 9003, 2001). However, it would be noted that only few sanitary landfills operated by Local Government Units (LGUs) complied with the minimum criteria set by the law such as the presence of liners, leachate collection and treatment system, gas control recovery system, groundwater monitoring well system, a cover, and closure and post closure procedures. This is by far the biggest challenge faced by Local government units because of financial limitations. There were lots of studies regarding solid waste management, however, there were relatively few studies conducted to assess the level of heavy metals contained in the landfills. In the study conducted by Galarpe and Parilla on analysis of heavy metals in Cebu Sanitary landfill in 2010, results revealed that the leachate stations exceeded the standard for lead (0.1968 mg/L) and mercury (0.14838mg/L). Groundwater stations in the landfill site also exceeded the standard for lead (0.0371 mg/L) and Cd (0.0042 mg/L). The

results could be alarming to public health and for the environment because heavy metals such as cadmium, lead and mercury are carcinogenic substances.

In Region I, there are about 125 disposal facilities (EMB, 2012) with only 16 functional sanitary landfills. Most of local government units are still on the process of converting their controlled dumpsite to sanitary landfill. In a controlled dumpsite, plastic liners are usually absent which should provide cover or protection to the leaching of contaminants to the water table found underneath. The local government units (LGUs) are mandated by the Department of Environment and Natural resources (DENR) to implement such criterion in the year 2005 as stipulated in RA 9003, however, due to financial and technical constraints, such policies were not properly implemented. The potential effects or impacts of waste disposal facilities may then become greater if there would be no constant monitoring and assessment on their status. The first established sanitary landfill is found in the City of San Fernando, La Union. Serving as a model to the adjacent towns, the municipality of Balaoan, about 33.5kilometers north of the city, also established its sanitary landfill in 2008 in compliance to RA 9003.However, there has been no data yet on the impact brought about by the disposal facility since it started operation. With this, there is a need to assess the status of the waste disposal facilities as to their impacts on the groundwater and to characterize the leachate quality in order to establish baseline information which in turn could be used in the formulation of policies for local waste management and health prevention in local government units.

Objectives

General Objective: To determine the groundwater and leachate quality from the waste disposal facility.

Specific Objectives:

1. Determine the groundwater quality of tube/deep wells adjacent or near waste disposal facility in terms of:
 - a. Physical parameters
 - b. Chemical parameters
 - c. Biological parameters
2. Characterize the leachates from the waste disposal facility in terms of toxic metals concentration.
3. Find out the deviation of the physico-chemical parameters of the groundwater and leachate water from the environmental quality standards.

Materials and Methods

Study Area

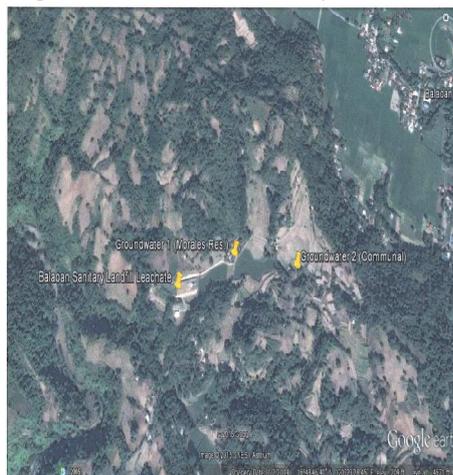
Balaoan is a first class municipality (Figure 1) which has a current population of 37, 910. With 36 barangays, its total land area is about 6,870 hectares (17,000 acres) consists mostly of agricultural lands. It occupies 4.3% of the total area of the province. With geographical coordinates of 16^o 19' 30" North, 120^o 22' 7" east, the municipality generates about 25.5 cu. M. of wastes/day. The town has been adjudged one of the outstanding municipalities because of its coastal resource management.

The study area (Figure 2) is the Balaoan Sanitary Landfill with a total land area of 1 ha. Originally, a marginal forest in Calumbuyan, the landfill is converted in 2008 in compliance to environmental laws particularly the RA 9003 known as the Ecological Solid waste Management Act of 2000. The bulk of the municipal wastes are mostly organics and inorganics composed of biodegradable and non-biodegradable wastes. These wastes when decayed results to leachate that would be contained in the leachate pond. The leachate pond is located between latitude 16^o 48' 42.9 'N and longitude 120^o 23 ' 21.2 ' with an elevation of 68 meters.

Figure 1: Municipality of Balaoan



Figure 2: Balaoan Sanitary Landfill



Water Analyses

Field survey was made to ascertain the presence of deep or shallow tube wells near the disposal facility. A shallow tube well and a communal deep well constructed from a flowing water (spring) were selected in a 500 m radius near the waste disposal facility where water samples were taken for analyses. In the study, the 1st groundwater sample was taken from a deep well from a residence nearby located between latitude 16° 48' 45.2" N and longitude 120° 23' 21.2" while the second ground water sample was obtained from a constructed shallow well located between latitude 16° 48' 44.3 "N and longitude 120° 23' 35.9 ". Grab sampling method were used and ground water samples were taken manually, placed in plastic and sterilized containers, properly sealed and labelled, and preserved with ice at lower temperature inside coolers for storage and transport ready for laboratory analyses. The sampling and analyses was conducted by CRL Environmental Corporation, an ISO accredited laboratory situated in Clark, Pampanga, Philippines during the months of February and April of the year.

The groundwater samples were analyzed in terms of physical, chemical and biological parameters such as pH, temperature, turbidity, conductivity, Total dissolved solids (TDS), nitrate, Total nitrogen, Total phosphorous, Total coliforms, and Fecal coliforms. The pH was measured using a calibrated pH meter and a glass electrode while the conductivity was measured by the use of self-contained conductivity meter. Total dissolved solids were measured following the gravimetric method. Turbidity was measured using the turbidity meter while nitrate was analyzed using the Cadmium Reduction method. Total Nitrogen and Total phosphorous were measured using the Total Kjeldahl Nitrogen and the colorimetric method respectively.

Leachate Concentration

Leachate is the liquid that drains or leaches from a landfill. It accumulates at the bottom of the landfill and percolates through the soil. The composition varies depending on the age of the landfill and the type of wastes that it contains. Further, the quality of leachate is determined primarily by the composition and solubility of the waste constituents (Khateeb, 2010). For instance, if the wastes changes in composition due to weathering or biodegradation, then leachate quality will change with time. The Balaoan Sanitary Landfill utilized the trench method of treatment whereby the liquid drains into a pond. In here, the delivered municipal wastes are dumped into the cell, compacted and covered with soil layer to minimize risk, reduce odors and reduce windblown garbage. The leachate pond was situated between 16°48'42.9." N and 120° 23' 21.2" During the sampling, it was noted that the pond was covered with water hyacinth- a water plant potential in waste water treatment. In this study, the leachate samples were also collected through grab sampling and placed in a plastic container properly sealed and labelled. The parameters such as

pH, chemical oxygen demand, total nitrogen, cadmium, chromium, copper, lead and mercury were considered for laboratory analyses.

Chemical **oxygen** demand (COD) is a measure of the capacity of water to consume oxygen during the **decomposition** of organic matter and the oxidation of inorganic chemicals such as **ammonia and nitrate** ([http:// science.jrank.org](http://science.jrank.org)). The COD measurement was done using the Open reflux method. The total nitrogen was measured taking the summation of Total Kjeldahl Nitrogen (TKN), nitrates and nitrites concentrations. The nitrates and nitrites were measured using the Cadmium Reduction method. Total Phosphorous was measured using the colorimetric method. The atomic absorption spectroscopy was used in the measurement of cadmium, chromium, copper and lead. Mercury measurement was done using the cold vapour technique.

Results and Discussion

Municipal solid wastes (MSW) usually generated from local government units which are not properly segregated would produce toxic chemicals that would pose a substantial risk to local resource user and to the natural environment. Non-hazardous municipal wastes, for example, produce leachate with near neutral pH in the early stages of decomposition, but as decomposition processes develop, waste becomes anaerobic and leachate may turn to a slightly to strongly acidic pH. It is also at this stage that ammonium and metal concentrations also rise. After several months or years, methanogenic conditions are established where the leachate becomes neutral or alkaline but with significant quantities of ammonia. Groundwater pollution by leachate from landfills is determined by factors such as the concentration of contaminant, permeability of the geologic strata, the type of geologic strata, the toxicity of the contaminants, and the direction of the water flow. Table 1 shows the test results of the groundwater samples taken from the two sites and the corresponding Philippine National Standards for Drinking Water (PNSDW) 2007 limits.

Table1: Summary of Results on Groundwater Samples in Balaoan Landfill

Parameters, units	1 st sampling		2 nd sampling		PNSDW 2007 Limits
	GW1	GW2	GW1	GW2	
pH	6.2	6.4	5.9	6.3	6.5-8.5
Temperature, °C	30.2	30.2	27.8	28.2	---
Turbidity, NTU	0.65	5.0	1.2	5.0	5.0
Conductivity, uS/cm	444	474	287	288	----
TDS, mg/L	320	341	214	161	500
Nitrate, mg/L	3.0	1.80	4.60	3.0	50
Total Nitrogen, mg/L	<1.0	<1.0	1.0	<1.0	---
Total Phosphorous, mg/L	<0.004	<0.1	<0.004	0.3	----
Total coliforms, MPN/100mL	>23	>23	>23	>23	<1.1
Fecalcoli forms, MPN/100m	3.6	3.6	>23	12	<1.1

Source: CRL Environmental Lab. Inc. 2015. (GW1- Groundwater station 1 GW2 – Groundwater station 2)

Based on the results analysed for the groundwater samples, total and fecal coliforms results are still the non-conforming parameters set by PNSDW. Other parameters tested such as pH, turbidity, conductivity, total dissolved solids, nitrate satisfies the PNSDW limits, though some parameters do not have corresponding limits. The pH of the water samples in both sampling stations did not conform to the PNSDW limits. The values showed slightly acidic which suggests that it could make a negative impact to aquatic life and human health. Total dissolved solids (TDS) comprise of inorganic salts such as magnesium, potassium, sodium, bicarbonates, calcium, chlorides and sulphates with some small amounts of organic matter that are dissolved in water. In the study, values for TDS are still below the standards, however, the values which ranged from 161 to 341 still indicates pollution. It would be noted, that the samples were taken during dry season (February and April) when precipitation is low, thus, the values for TDS are expected to increase when precipitation also increases. The conductivity of the water showed appreciable values which

ranged from 287 to 474. This means that the water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulphate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminium cations (ions that carry a positive charge). Conductivity is closely associated to salinity. Conductivity increases as temperature increases. Nitrates may get into the drinking water through run-off from fertilizers, leaks from septic tanks, sewage and erosion of natural deposits. As gleaned from the results, the water samples in both stations showed very minimal amounts as based from the PNSDW limit. However, EPA maximum contaminant level (MCL) is 10mg/L. Total coliforms result is the estimate of the amount or density of rod-shaped coliform bacteria and an indicator of drinking water quality. Coliform bacteria are common inhabitants in soils, plants and animals that may come in contact with water. They are not harmful but their presence may also indicate the presence of pathogens from fecal origins and other disease causing microorganisms. The results suggests that the water taken from these deep wells should not be used for drinking purposes as this may cause health problems associated with these pathogens which include diarrhoea, cramps, nausea, and vomiting (<http://water.epa.gov/lawsregs/rulesregs/sdwa/tcr/basicinformation>). As observed, the second station is a communal source of drinking water since this is spring water.

The location of the landfill has a significant impact in the process of leaching. The location of the groundwater sampling sites to that of the leachate well (figure 2) were positioned below the leachate well since groundwater 1 has an elevation of 62 meters; groundwater 2 is 59 meters while leachate pond is positioned 68 meters above sea level. The contamination of the wells could be hardly associated with leachate percolation, however, the surface runoff during precipitation which runs over the groundwater sites could possibly contaminate the wells and may be aggravated by the improper practices like laundering clothes, washing and bathing near the source by the local water users. Mor (2005) emphasized in his study on the strong relationship between depth and distance from landfills with groundwater samples. Water samples taken from wells adjacent to the landfill were the most vulnerable to pollution and decrease of contaminants results as the horizontal distance from landfills increase. In the same manner that, leachate concentration increase with depth and decrease with increasing water addition. In Balaoan sanitary landfill, the groundwater samples though adjacent to the study area, were found not contaminated with toxic chemicals. Table 2 shows the summary results of the leachate water during the 1st and the second sampling and the corresponding DENR Administrative Order(DAO) No. 35, Class C standards.

Table 2: Results of Leachate Water

Parameters, units	1 st sampling	2 nd sampling	DAO 35, Class C stds
pH	6.6	8.8	6.5-9.0
Chemical Oxygen demand,mg/L	88	39	100
Total nitrogen,mg/L	6.0	<1.0	---
Cadmium, mg/L	<0.006	<0.006	0.05
Chromium,mg/L	<0.02	<0.02	----
Copper, mg/L	<0.01	<0.01	----
Lead, mg/L	<0.05	<0.05	0.5
Mercury,mg/L	<0.0001	<0.0001	0.005

Source: CRL Environmental Laboratories, Inc., 2015

As gleaned from the results, pH of the leachate water revealed slightly basic in the second sampling. The types of wastes may have made the change of pH as well as the decomposition which may have become faster due to intense heat. In here, the organic and inorganic materials were converted by anaerobic microorganisms to methane gas and other products such as ammonia and sulphates depending on the type of wastes present. From the waste data (EMB-DENR, 2013) Balaoan Sanitary Landfill generates 2.0 cu.m of wastes/ day. The Chemical Oxygen Demand (COD) result obtained is below the regulatory limit of 100 mg/L. COD is a measure of the oxygen-depleting capacity of waste water and is equivalent to the amount of oxygen needed to oxidize the pollutants. Noticeably, water hyacinth covers the leachate pond. In the study conducted by Maharjan and Ming (2012), water hyacinth has the potential to treat waste water. Results of their studies showed reduction of pollutants/nutrients particularly in the concentration reduction in BOD, Total Nitrogen, Total Phosphorous, and Fecal Coliform. The results of this study showed

similar results. The concentration of cadmium, chromium, copper, lead and mercury are way below the regulatory limits and this implies that the leachate contains very minimal toxic metals that would contaminate the groundwater. Further, this implies the good waste management practices implemented by the local government units where wastes are being segregated before land filling. The LGU has also a bio reactor installed in their material resource Facility (MRF) for composting biodegradable wastes.

Summary and Findings

1. The physicochemical parameters such as pH, temperature, turbidity, conductivity, total dissolved solids, nitrates, total nitrogen, and total phosphorous conformed to the water quality standards set by PNSDW.
2. Total and fecal coliform counts do not conform to corresponding PNSDW limits
3. The Chemical Oxygen Demand and concentrations of the toxic metals such as cadmium, chromium, copper, lead, and mercury are far below the allowable limit.

Conclusion and Recommendation

1. Based on the obtained results, biological parameters such as total and fecal coliforms results of the groundwater samples from both sampling sites did not conform to the water quality standards set by PNSDW, thus, not advisable for human consumption. It is necessary that water taken from the wells be properly treated either by boiling of water, chlorination or water purification. pH of the water samples should be closely monitored for potential health risks associated to acidic water.
2. The conductivity of the groundwater samples from both stations showed appreciable values which when ignored may lead to undesirable water quality not fit for human consumption.
3. The Local Government Unit (Municipality of Balaoan) should continue its good waste management practices of segregating wastes before land filling for reduction of contaminants especially the toxic metals that would be carried through surface water runoff.

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