Michael Okpara University of Agriculture, Umudike

College of Natural Resources and Environmental Management

Department of Forestry and Environmental Managment

Topic

ASSESSMENT OF LEACHATE ON GROUNDWATER QUALITY – CASE STUDY OF ENYIMBA OPEN DUMPSITE, OSISIOMA NGWA LOCAL GOVERNMENT AREA, ABIA STATE

By

HARRY, PRINCE INEMEAWAJI

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Water is a substance composed of the chemical elements hydrogen and oxygen and existing in gaseous, liquid, and solid states. It is one of the most plentiful and essential of compounds. A colourless, tasteless, and odourless liquid at room temperature, it has the important ability to dissolve many other substances. Indeed, the versatility of water as a solvent is essential to living organisms, especially for drinking. Water is one of the determinant of human earth system and as a precious resource, water needs to be valued and conserved (Anju *et al.*, 2015).

However in several parts of the world, humans do not have any access to safe drinking water, due to the fact that the water is contaminated. Access to safe drinking water remains an urgent necessity, as most of the urban and rural population still depends completely on untreated surface or groundwater resources (Ashwani and Abhay, 2014).

Groundwater occurs in many different geological formations. Nearly all rocks in the upper part of the Earth's crust, whatever their type, origin or age, possess openings called pores or voids. The volume of water contained in the rock depends on the percentage of these openings or pores in a given volume of the rock, which is termed the porosity of the rock. More pore spaces result in higher porosity and more stored water (Mohammad *et al.,* 2014). Most of the Earth's liquid freshwater is found, not in lakes and rivers, but is stored underground in aquifers. Indeed, these aquifers provide a valuable base flow supplying water to rivers during periods of no rainfall. They are therefore an essential resource that requires protection so that groundwater can continue to sustain the human race and the various ecosystems that depend on it. The contribution from groundwater is vital; perhaps as many people depend directly upon aquifers for drinking water, and large amount of the world's food is produced by irrigated agriculture that relies largely on groundwater. In the future, aquifer development will continue to be fundamental to economic development and reliable water supplies will be needed for domestic, industrial and irrigation purposes (Mohammad *et al.*, 2014). Groundwater is an important source of water as it constitutes about 95 per cent of the freshwater on our planet (discounting that locked in the polar ice caps), making it fundamental to human life and economic development, but is being mostly polluted due to the presence of open dumping sites.

The waste deposited in open dumpsites immediately becomes a part of the prevailing hydrological system. Fluids derived from rainfall, snowmelt and groundwater, along with liquids generated by the waste itself through processes of hydrolysis and solubilization, caused by an entire series of complex biochemical reactions during degradation of organic wastes, percolate through the deposit and mobilize different component within the waste. The leachate accumulates at the bottom of the landfill and percolates through the soil (Mor *et al.*, 2006). This leachate, the liquid drains from the dump, chiefly organic carbon largely in the form of fulvic acids migrate downward and contaminate the groundwater (Ugwu and Nwosu, 2009). The major environmental problem at landfills is the loss of leachate from the site and the subsequent contamination of groundwater (Jagloo, 2002).

Dumpsites have been identified as one of the major threats to groundwater resources receiving a mixture of municipal, commercial and mixed industrial wastes. The depressions into which solid wastes are often dumped include valleys and excavations. Studies on the effects of unlined waste dumps on the host soil and underlying shallow aquifers have shown that soil and groundwater system can be polluted due to poorly designated waste disposal facilities (Amadi *et al.*, 2012). So many waste dumpsites are located at various parts of Aba municipalities and its environs, apparently based on other reasons than convenience. Some of these sites are indiscriminately located at streams, valleys, open fields, wetlands and in abandoned borrow pits (Ukpong, *et al*, 2015). Studies by Aluko, (2001), and Akinbiyi, (1992) have shown that there is an unconditional water rest aquifer underlying most area of Aba and its environs upon which all depend for their various needs including drinking water.

The dumpsite that was assessed contains both biodegradable and non-biodegradable materials of all sorts which may contain different physical, chemical and microbiological properties. The accumulation of waste in Osisioma Local Government mostly in Enyimba reduces the aesthetic value of the place and increases the rate of diseases among the individuals occupying these areas. It also increases the breeding conditions of some disease vectors and pathogens which invariably increases the morbidity (Malaria, dysentery and diarrhea) and mortality (Civeria and Lavado, 2008) as well as the cost of medical expenditure among the local residents (Ejeona and Umah, 2000).

From my reconnaissance survey, it was observed that boreholes serve as the source of underground water from which people around Enyimba depend on as their source of drinking water. This is because the surface water (Stream) around the area is polluted by industrial effluents and other commercial activities. Since boreholes are the only source of drinking water, the quality of this underground water medium is disturbed by indiscriminate dumping of waste around the area, which leads to the contamination of underground aquifers. Water-borne diseases may spring up through water pollution, especially groundwater contamination, and rapidly spread beyond human expectation because of its flow mechanism (Afolayan *et al.*, 2012).

1.2 Statement of Problem

Every living organism depends on water in one way or the other for their daily living. Most Nigerians, especially people in Enyimba and its environs depend on borehole water as a source of drinking water and for other domestic activities and if this water source is contaminated the health of these individuals are at stake.

Waste of different types, mostly solid wastes are the major input of dumpsites/landfills. With respect to the hydrological analysis of groundwater, it flows from areas of higher topography towards areas of lower topography, thereby bringing about the examination of the degradable material which form leachate and contaminate the groundwater of the study area. Groundwater quality has become an important water resources issue due to rapid increase of population, rapid industrialization, unplanned urbanization and too much use of fertilizer and pesticides in agriculture (Joarder *et al.*, 2008). Thus, since groundwater pollution data are generally scarce, chemical analysis of water samples need to be specific to detect their presence. This is because the environment, economic growth and development of Nigeria are all highly influenced by water, including its regional and seasonal availability as well as its antecedent quality (Obiefuna and Orazulike, 2010). It is therefore essential to examine the water quality in this area especially those around the dumpsite to ascertain its impact on groundwater quality.

1.3 Justification

This study is necessary because it is hoped that through its outcome, the magnitude of the environmental contamination in the study area will be highlighted. I believe that the findings of this work will serve as a basis for other researchers working or who will intend working on water quality. The people in the area consume these borehole water without considering it contaminated this is because their major indicators for contaminated water is based on some physical parameters, like taste, colour and odour without taking into consideration the other physical, chemical and biological variables of water (Oyiboka, 2014).

1.4 Aims and Objectives

The aim of the research is to examine the effect of leachate on borehole water quality: a case study of Enyimba open dumpsite, Osisioma Ngwa Local Government Area, Abia State. The study will particularly:

- Examine the effect of distance from dumpsite on the physical, chemical and biological properties of sampled water.
- Examine if there is concentration variation in water quality among sampled groundwater sources and sampled leachate from the dumpsite.
- Compare the difference in the quality of sampled water with international limits.

1.5 Limitation

Most of the owners of the boreholes refused to cooperate due to their belief that the researcher was sent by the government to expose their non-compliance to water standards of the country. Some also believe that if the work is published will lead to the closing down of their boreholes and refuse to assist since that is their means of survival. The high cost of testing each sample affected the number of samples tested.

CHAPTER TWO

LITERATURE REVIEW

A great number of scholars from various fields made a lot of contributions on the issues of environmental impact of waste through sound programs or studies. In the quest for previous knowledge, attempt was made to review a number of these literatures from journals, books, electronic devices, newspapers, articles and magazines.

2.1 Meaning of waste

Waste is any substance which is discarded after primary use, or it is worthless, defective and of no use. Waste is any material that has no re-usable capability. Waste can be generated in various ways e.g. from domestic activities, industrial, commercial and institutional activities. Due to an increase in human population, waste generated has increased at an alarming rate. Most of the things called waste, when studied thoroughly are not deemed waste because they can be recycled and re-used.

2.1.1 Solid Waste

The Federal Environmental Protection Agency (FEPA) (1995) defined solid wastes as useless, unwanted or discarded materials that arise from man's activities and cannot be discarded through sewer pipe. The United States Environmental Protection Agency (EPA) defined solid waste as "any useless, unwanted or discarded materials with insufficient liquid content to be free flowing. Adequate treatment of waste is required before discharge into the environment (Nouri *et al.*, 2006). Municipal Solid Waste (MSW) disposal is a global concern (Aderemi *et al.,* 2011), especially in developing countries across the world, as poverty, population growth and high urbanization rates combine with ineffectual and under-funded governments to prevent the efficient management of wastes (Cointreau, 1982 ; Doan, 1998).

Solid waste may be classified based on source, state and effect. Based on the source, waste can be classified as industrial, commercial, agricultural, domestic and institutional, while based on state we have; liquid, gaseous, semi-solid and solid. Solid wastes that make up a refuse is categorized into biodegradable and non-biodegradable. Waste generation is influenced by urbanization, population growth, economic growth, consumption pattern and industrialization. In Nigeria, a variety of wastes originating from domestic and industrial sources find their way into streams and rivers due to a weak enforcement of existing legislation and lack of basic infrastructure, such as sewers and hygienic disposal facilities (Sridhar and Ademoroti, 1984).

2.2 Solid Waste Dumpsite

A solid waste dumpsite may be any area or site designated for the disposal of waste. The most used forms of Solid waste dumpsite can be categorized into Open dumps system and Sanitary landfill system.

2.2.1 Open Dump System

In the developing world the prevailing method for the disposal of municipal and domestic refuse is usually open dumping, often coupled with waste burning with minimal effort directed towards land filling practice e.g. the use of daily cover (Me-Stuart and Klinck, 1998). In Nigeria, like many other developing countries, open dumping has been the only management option of solid waste disposal. In previous years management system has been based on collection and dumping out of the city boundaries in conformity with the concept of "out of sight out of mind" (Arukwe *et al.*, 2012).

2.2.2 Sanitary Landfill

Landfill may be any physical facility, designed, constructed and managed for the disposal and management of waste. These landfills are operated by agencies, governmental bodies and other non-governmental bodies for the management of waste and the control of waste polluting the environment. Landfills are usually either placed above ground or contained within quarries, pits. Landfills are sources of groundwater and soil pollution due to the production of leachate and its migration through refuse (Misra and Mani, 1991).

Land filling is the simplest, cheapest and most cost effective method of disposing of waste in both developed and developing nations of the world (Barrett and Lawlor, 1995). Landfills have been identified as one of the major threats to groundwater resources (Fatta *et al.*, 1999; USEPA, 1984). From the past to the present, disposal of waste into landfills has been the preferred method of waste disposal both from an economic and environmental point of view. Even where well planned waste reduction, recycling and transformation are in place. The residual waste from such operations still ends up on a landfill. Therefore, landfills will remain an integral part of the integrated waste management strategy for a long time (Ejlertsson and Svenssor, 1997). The ideal landfill is one which is confined to a small area and is covered with layers of soil. It is also required to have a liner at the bottom of the pit to prevent leachate or the liquid from solid waste to seep through and contaminate the water supply. Additionally, a landfill must have groundwater testing, leachate treatment systems, and it must be covered with soil daily to avoid the emission of unpleasant odours and invasion of pests.

2.2.3 Comparison between Sanitary Landfill and Dumpsites

- **Sanitary landfill**

A sanitary landfill is an engineered system while a dump is a random site that allows the collection of waste. In most cases, construction of sanitary landfills do occur where groundwater and runoff is not the problem. Local municipalities and residents must be considered. Avoidance of burning, well trained staff and modern equipment must be provided (Oyiboka, 2014). According to Emelda (2011) waste disposal is one of the biggest problems that the world is facing. In man’s everyday life, he produces waste materials which, if not properly managed, can lead to health and environmental problems. Governments are faced with finding the most effective waste disposal and management systems to use.

Once a landfill is filled, a new one is created. Old landfills can be sources of toxins which are caused by the inability of waste materials to rot naturally. Because landfills are good sources of recyclable materials, they draw scavengers who face the risk of being buried under the pile of rubbish if they are careless. While dumps and landfills are used to address the waste problems, in the long run they can become health and environmental hazards. A sanitary landfill holds municipal solid waste, construction debris, and some type of agricultural and industrial waste. A landfill has a liner at the bottom to trap the liquid produced by solid waste while a dump does not have a liner. Landfills are covered daily with soil to deter pests and prevent bad smells from being released into the air. It also helps to control the speed of rot as water and air do not readily enter the landfill. Landfills are basically designed in such a way that the garbage is stored without damaging the environment.

- **Open dumpsite**

An open dump or dumpsite is essentially a large hole in the ground into which rubbish is dumped. The hole may be disused quarry, open cast mine or clay pit which is then used as a place to dump rubbish (Oyiboka, 2014).A few decades ago when the human population was not as large as it is today, waste disposal was easily managed. People used dumps which are excavated pieces of land or pits where waste materials are stored. Most households, especially those in rural areas, have dumps while urban communities have a common dump for their residents. Dumps are not regulated by the government and they lack processing control. They can be found anywhere and may or not be covered with soil. They are also not monitored and the chances of the liquid produced by solid waste contaminating the water supply are great.

Open dumps can attract pests such as flies and rats and emit bad odours which are hazardous to man. Because of this, dumps are considered illegal and have since been replaced with landfills. Communal dumps have been converted to landfills which are regulated by the government.

In summary, a dump is an excavated piece of land used as storage for waste materials while a landfill is also an excavated piece of land for waste storage but is regulated by the government. Dump is smaller than a landfill. Dumps do not have leachate collection and treatment systems while a landfill does. Dumps on the other hand are hardly covered unlike landfills, speeding up the rot process and releasing toxic gases into the air.

2.3 Solid Waste Management

Wastes are generated annually and there is no space for the dumping of these wastes, especially in developing countries. These waste if not properly managed may bring about some environmental and health hazards. The collecting, treating, and disposing of solid material that is discarded because it has served its purpose or is no longer useful. Improper disposal of municipal solid waste can create unsanitary conditions, and these conditions in turn can lead to pollution of the environment and to outbreaks of vector-borne disease-that is, diseases spread by rodents and insects. The tasks of solid-waste management present complex technical challenges. They also pose a wide variety of administrative, economic, and social problems that must be managed and solved.

A technological approach to solid-waste management began to develop in the latter part of the 19th century. Watertight garbage cans were first introduced in the United States, and sturdier vehicles were used to collect and transport wastes. A significant development in solid-waste treatment and disposal practices was marked by the construction of the first refuse incinerator in England in 1874. By the beginning of the 20th century, 15 percent of major American cities were incinerating solid waste. Even then, however, most of the largest cities were still using primitive disposal methods such as open dumping on land or in water.

Technological advances continued during the first half of the 20th century, including the development of garbage grinders, compaction trucks, and pneumatic collection systems. By mid-century, however, it had become evident that open dumping and improper incineration of solid waste were causing problems of pollution and jeopardizing public health. As a result, sanitary landfills were developed to replace the practice of open dumping and to reduce the reliance on waste incineration. In many countries waste was divided into two categories, hazardous and nonhazardous, and separate regulations were developed for their disposal. Landfills were designed and operated in a manner that minimized risks to public health and the environment. New refuse incinerators were designed to recover heat energy from the waste and were provided with extensive air pollution control devices to satisfy stringent standards of air quality. Modern solid-waste management plants in most developed countries now emphasize the practice of recycling and waste reduction at the source rather than incineration and land disposal.

2.3.1 Importance of Solid Waste Management

In communities where appropriate sites are available, sanitary landfills usually provide the most economical option for disposal of non-recyclable refuse. However, it is becoming increasingly difficult to find sites that offer adequate capacity, accessibility, and environmental conditions. Nevertheless, landfills will always play a key role in solid-waste management. It is not possible to recycle all components of solid waste, and there will always be residues from incineration and other treatment processes that will eventually require disposal underground. In addition, landfills can actually improve poor-quality land. In some communities properly completed landfills are converted into recreational parks, playgrounds, or golf courses.

2.4 Leachates

This term is known widely within the Landfill industry and is of paramount importance to the environment. According to several studies, it has been established that leachate is formed from waste decomposition, several environmental, biochemical and microbial reactions. Leachate is generated from decomposition of garbage and precipitation that infiltrates and percolates downward through the volume of waste material. When leachate reaches and mixes with groundwater or seeps into nearby bodies of surface water, public health and environmental quality are jeopardized. Leachate generally comes into existence during dissolution in the in the landfill. The environments can be polluted by the leachate, which occurs at the end of decayed solid waste, mixed with precipitates of surface water (Salami *et al.,* 2014).This leachate accumulates at the bottom of the landfill and percolates through the soil (Mor *et al.,* 2006). The physical appearance of leachate when it emerges from a typical landfill site is a strongly odoured black, yellow or orange coloured cloudy liquid. The smell is acidic and offensive and may be very pervasive because of hydrogen, nitrogen and sulfur rich organic species such as mercaptans (Obare, 2014).

Degradation end products of waste components like food, paper and textiles consumes oxygen thereby changing the oxidation-reduction potential of the liquid present and probably influence quality of different constituents. Percolating rainwater provides a medium in which waste, particularly organics, can undergo degradation into less complicated substances through biochemical of organic chemistry reactions involving dissolution, hydrolysis, oxidization and reduction, processes controlled to a large extent within landfills and dumps by microorganisms, primarily bacteria. Due to the decomposition of organic matter, leachate derived from landfills or dumps comprises primarily dissolved organic carbon, for the most part within the form of fulvic acids (Christensen *et al*., 1998).

2.4.1 Leachate Production

2.4.1.1Influence of Source

In a landfill that receives a mixture of municipal, commercial, and mixed industrial waste, but excludes significant amounts of concentrated specific chemical waste, landfill leachate may be characterized as a water-based solution of four groups of contaminants; dissolved organic matter (alcohols, acids, aldehydes, short chain sugars etc.), inorganic macro components (common cations and anions including sulfate, chloride, iron, aluminum, zinc cadmium, selenium, fluorine and ammonia), heavy metals (Pb, Ni, Cu, Hg), and xenobiotic organic compounds such as halogenated organics, (PCBs, dioxins, etc.). Domestic waste and agricultural waste e.g. fertilizers when decompose may not produce the same quality of leachate. Leachate produced in a dumpsite may also reacts with materials that are not themselves prone to decomposition such as fire ash, cement based building materials and gypsum based materials changing the chemical composition. In sites with large volumes of building waste, especially those containing gypsum plaster, the reaction of leachate with the gypsum and decaying cabbages can generate large volumes of hydrogen sulfide which may be released in the leachate and may also form a large component of the landfill gas. When the gas is dissolved, a weak sulphuric acid is produced (Obare, 2014).

2.4.1.2 Leachate processes and Landfill Life Span

Leachate quality varies throughout the operation life of a landfill and long after its closure. There are three broad and overlapping phases of waste decomposition, in which chemical and biological processes give rise to both landfill gas, and leachate during and beyond the active life of the site. According to Kostova, 2006, concentration (mg/L) of leachate constituent are in phases namely; transition (0-5 years), acid-formation (5-10 years), methane fermentation (10-20 years) and final maturity (>20 years). The age of a landfill also significantly affects the quantity of leachate formed. The ageing of a landfill is accompanied by increased quantity of leachate. Leachate generated in the initial period of waste deposition (up to 5 years) in landfills, have pH-value range of 3.7 to 6.5 indicating the presence of carboxylic acids and bicarbonate ions. With time, pH of leachate becomes neutral or weakly alkaline ranging between 7.0 and 7.6. Landfills exploited for long period of time give rise to alkaline leachate with pH range of 8.0 to 8.55 (Slomczynska and Slomczynski, 2004; Longe and Balogun, 2010).

2.4.1.3 Leachate Migration

Modern landfills have liners at the base, which act as barriers to leachate migration. Leachate migration is also affected by the type of waste deposited. Compaction of waste before deposition reduces its permeability, whereas regular application of a topsoil cover between the loadings of waste to landfills induces layering. These characteristics inevitably bring about to preferential flow paths through landfills (Johnson *et al.*, 1998).

In an open dump, the leachate that is produced during the decomposition of solid easily percolates through the soil to the groundwater table, contaminating the water resource. This is as a result of the absence of liners and a well-structured design.

However Lee and Kitanidis, (1993) stated that leachate migration from disposal sites can be influenced by site design, waste type, hydrogeology, geochemistry and climatological conditions. A rigorous analysis which takes all these factors into consideration is a formidable task.

2.4.1.4 Characteristics of Leachate in Groundwater Quality

In recent times, the impact of leachate on groundwater and other water resources has attracted a lot of attention because of its overwhelming environmental significance. Leachate migration from wastes sites or landfills and the release of pollutants from sediments (under certain conditions) pose a high risk to the groundwater resources if not adequately managed (Ikem *et al.*, 2002). It has been widely reported that leachates from landfills for non-hazardous waste could as well contain complex organic compound, chlorinated hydrocarbons and metals at concentrations which pose a threat to both surface and groundwater. The produced leachate is normally composed of organic and inorganic compositions. In addition, as time elapses, the produced leachate permeates into ground systems leading to change of physical and chemical properties of groundwater (Vasanthi *et al*., 2008).

2.5 Water Quality Standards in Nigeria

The Nigerian Standard for Drinking Water Quality (NSDWQ) was approved by the Council of the Standards Organization of Nigeria in 2007 specifying upper and lower limits of contaminants known to pose a risk to the wellbeing of individuals (NIS, 2007). Table 2.1 provides a comparison of the World Health Organization's standard of water quality with that of the Nigerian Standard for Drinking Water Quality. From Table 2.1, minor differences exist between World Health Organization (W.H.O.) and Nigerian Standard for Drinking Water Quality (NSDWQ), in the standards of measuring the minimum and maximum concentration of water quality.

Table 2.1 Water quality variables and their standard limits

Parameter		Units	W.H.O.	NSDWQ
1	Temperature	^{0}C	25	NS
2	pH	NS	6.5-8.5	6.5-8.5
3	Electrical Conductivity(EC)	(µScm-1)	1000	1000
4	Total Suspended Solid(TSS)	Mg/L	3.0mg/l	NS
5	Total Hardness(TH)	Mg/L	100mg/l	150mg/l
6	Chloride(Cl-)	Mg/L	250mg/l	250mg/l
7	Nitrate(N03-)	Mg/L	10mg/l	50mg/l
8	Dissolved Oxygen(O2)	Mg/L	2.0mg/l	NS
9	Iron(Fe)	Mg/L	0.03mg/l	0.3mg/l
10	Lead(Pb)	Mg/L	0.01	0.01mg/l
11	Total Acidity	Mg/L	NS	NS
12	Total Alkalinity	Mg/L	200mg/l	NS
13	Sodium(Na)	Mg/l	200mg/l	NS

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