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Impact of Open Dumpsite Leachate on Groundwater Quality in Oyigbo, Rivers State, Nigeria

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Abstract- The study investigated the impact of open dumpsite leachate on groundwater quality by examining the physical and chemical properties of groundwater within the vicinity of Oyigbo in Rivers State, Nigeria. Physical and chemical analysis of groundwater samples from three (3) boreholes which constitutes a major source of water for domestic purpose was carried out to assess the quality in view of the proximity of the wells to open solid waste disposal sites. Results show that the water is weakly acidic with pH level ranging from 5.4-6.23; a very soft groundwater with Total Hardness ranging from 1.5-7 mg and low in Total Dissolve Solids (TDS) from 5-55 mg/l. Results from other chemical parameters tested are Cl^- ranging from 50-100 mg/l, SO_4^{2-} has 0.01-1.54 mg/l, NO_3 ranging from 0.035-0.104 mg/l, Total Suspended Solid (TSS) ranging from 0.1-0.3 mg/l, Chromium with 1.08-4.52 mg/l, Cadmium having 0.01-0.03 mg/l, Lead ranging from 0.1-0.39 mg/l, Iron with 0.95-1.53 mg/l, BOD ranging from 9.8-12.8 mg/l, COD with 153.57-171.37 mg/l and DO ranging from 7.1-10 mg/l. The parameters exceeding the allowable limit of WHO standards include Cadmium, Lead, Iron, Chromium, COD, DO and BOD, all major ions revealed concentration within the acceptable limit of the WHO standard. The impacts of indiscriminate dumping activity on groundwater appeared most clearly as high concentrations of Cadmium, Lead, Iron, Chromium, COD, DO and BOD were detected. The study has revealed that the groundwater quality near dumping sites does not conform to the drinking water quality as per WHO standard. The results confirm the need for determining safe distances between wells and waste disposal sites to abate groundwater pollution.

Indexed Terms- Open Dumpsite, Leachate, Groundwater Quality

I. INTRODUCTION

Municipal solid waste disposal has been a serious global concern most especially in developing countries across the world, as poverty, population growth and high urbanization rates combine with ineffectual and underfunded government to prevent proper management of wastes. In urban areas of most developing and least developed countries, generated solid waste is at best collected and dumped in arbitrary dump sites which most times lack the appropriate norms. Such disposal requires collecting, conveying and dumping into the nearest open space area. In other countries, municipal solid waste is disposed into water bodies and wetland and part of the waste is burned to reduce its volume. Such practices have their harmful environmental impact which ranges from polluting the natural resources and the ecology to the creation of health problems which might result into long-term public health problems. Open dumps are the oldest and most common way of disposing solid wastes, and although in recent years thousands of them have been closed, many are still being used [1]. Waste disposed in an open dumpsite are subject to either groundwater underflow or infiltration from precipitation and as water percolates through the waste, it picks up variety of organic and inorganic compounds flowing out of the waste and accumulates at the bottom of the dumpsite.

The resulting contaminated water is termed "leachate" and can penetrate through the soil and eventually contaminate the groundwater if not adequately managed [2]. Such contamination of groundwater resources can pose serious health risks, including waterborne diseases such as typhoid, cholera and infectious dysentery, to the local groundwater users.
Improper solid waste management leads to substantial negative environmental impacts (for example, pollution of air, soil and water, and generation of

greenhouse gases from landfills), and health and safety diseases associated with different forms of pollution at local and global levels [3]. A number of incidences have been reported in the past, where leachate had contaminated the surrounding soil and polluted the underlying ground water aquifer or nearby surface water. Even if there are no hazardous wastes placed in municipal landfills, the leachate is still reported as a significant threat to the groundwater [3].

Water is the most abundant environmental resource on earth but its accessibility is based on quality and quantity, as well as space and time. It may be available in various forms and quantity but its use for various purposes is the subject of the quality. About 70% of the human body and about 60-70% of plant cells is made up of water [4]. It is one of the determinants of human settlement, existence and activities on earth. Its quality is fixed but dynamic in formation and storage. The major sources of water are surface water (oceans, rivers, streams seas and brooks), groundwater, snow and ice, and lakes. However, their exploration and exploitation vary from place to place based on their state of existence. Groundwater plays a vital role for urban and agricultural water supply. It constitutes a major portion of the earth's water circulatory system known as hydrological cycle and occurs in a permeable geological formation known as aquifers i.e. formations having structures that can store and transmit water rates fast enough to supply reasonable amounts to well [5]. Once contaminated, groundwater may forever remain polluted without remedy or treatment. Water is one of the determinants of human earth system. Diseases may spring up through water pollution, especially groundwater contamination and rapidly spread beyond human expectation because of its flow mechanism [5]. With respect to the hydrological analysis of groundwater, it flows from areas of higher topography towards area of lower topography, thereby bringing about examination of the degradable materials which form leachate and contaminate the groundwater of the study area.

Groundwater is the major source of potable water in the study area and Rivers state in general. The town relies on boreholes (water wells) as sources of drinking water hence poor drinking water quality may have health consequences. Groundwater recharge is the replenishment of an aquifer with water from the land surface [6]. Groundwater systems are dynamic and water is continuously in slow motion down gradient from areas of recharge to areas of discharge [7]. During recharge, water is pulled downward into the earth by gravity through two zones; the upper zone called the zone of aeration, where a mixture of water and air fills the pore spaces. Below the zone of aeration is the zone of saturation where the pore spaces are completely filled by water. The surface of the groundwater exposed to an atmospheric pressure above the surface of the saturated zone (aquifer) is known as the groundwater water table. The water table can be as shallow as a foot below the ground or it can be a few hundred meters deep. Heavy rains can cause the water table to rise and conversely, continuous extraction of groundwater can cause the level to fall. Underground strata that can both store and transmit accumulated groundwater to outlets in rivers, springs and the sea are termed aquifers. There are two different types of aquifers based on physical characteristics: if the saturated zone is restricted between layers of impermeable material and the groundwater is under pressure, it is called a confined aquifer; if there is no impermeable layer immediately above the saturated zone, it is called an unconfined aquifer. Groundwater quality comprises the physical, chemical, and biological qualities of ground water. Temperature, turbidity, colour, taste, and odour make up the list of physical water quality parameters [8]. Examples of water chemical properties include: alkalinity, acidity, pH and total hardness. Since most ground water is colourless, odourless, and without specific taste, more attention will be focused on chemical and biological qualities. Hydrochemical evaluation of groundwater system is usually based on availability of a large amount of information concerning groundwater chemistry. The quality of groundwater is as important as its quantity owing to the suitability of water for various purposes. Groundwater chemistry, in turn, depends on a number of factors such as general geology, degree of chemical weathering of various rock types, quality of recharge water and inputs from sources other than rock interaction. Such factors and their interaction result in a complex water quality [9]. Groundwater quality is determined by natural and anthropogenic factors. Factors affecting groundwater are nature of bedrock geology, depth from surface soil, vegetation, climatic variation, permeability of sediments, and topography, while anthropogenic are nature of human activities, urbanization, industrialization and waste management disposal, amongst others. Decomposition of organic matter can alter the physicochemical quality of groundwater and promote the mobility of dangerous chemical, involving metals and solvents.

Groundwater pollution is caused by the presence of undesirable and hazardous material and pathogens beyond certain limits. Much of the pollution is due to anthropogenic activities like discharge of sewage, effluents and waste from domestic and industrial establishment. Although the soil mantle through which water passes acts as an adsorbent retaining a large part of colloidal and soluble ions with its cation exchange capacity, but ground water is not completely free from the menace of chronic pollution [10]. He further pointed out that Water pollution is increasing steadily due to rapid population growth, industrial proliferations, urbanizations, increasing living standards and wide spheres of human activities.

Study found that continuous disposal of industrial effluents on land, which has limited capacity to assimilate the pollution load, has led to groundwater pollution [11], [12]. The prospect of an arsenic contamination crisis has particularly caught the attention of leaders and expert. Sources of major concern to groundwater pollution include leachate from pit latrines, solid waste dumpsites, industrial effluents, domestic wastes, sea water intrusion, agricultural chemicals, and oil spillage. These sources can generate many types of pollutants including heavy metals, nitrogen species, chlorinated hydrocarbons phenols, cyanides, and bacteria among others [13]. An open dump is a random site that allows the collection of waste. Open dump has been referred to as the ultimate means of survival for the less privileged people in developing countries of the world, especially in Africa.

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. 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.

The greatest contamination threat to groundwater comes from the leachate generated from the material which often contains toxic substances especially when wastes of industrial origins are land filled [14]. However, 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 impact of dumpsite leachate on the surface and groundwater has given rise to a number of studies in recent years [15]. Leachate from dumpsite has been reported as a significant threat to groundwater even if it does not contain hazardous wastes. Leachate derived from waste deposits (landfills, refuse dumps) includes a wide range of contaminations, depending on the types of waste deposited.

The likelihood of disposed wastes polluting groundwater is the function of the unsaturated zone and the attenuation capacity of the underlying site, and also on the total and effective precipitation at the site, since the quality and concentration of leachate generated is a function of the access of water to the waste. Also, the situation of groundwater pollution is more pronounced during the rainy season owing to the rate of leachate infiltration, percolation and migration. Leachate migration from disposal sites can be influenced by site design, waste type, hydrogeology, geochemistry and climatological conditions.

II. MATERIALS AND METHODS

A. Study Area Description

The study was conducted within Oyigbo town in Rivers State, Nigeria which was the dumpsite of the Rivers State management in Oyigbo local government area (See Fig.1). The study area thus covers an area of over 248 km^2 with a population density of 710.1/km^2. The Oyigbo landfill is located within latitudes 4° 52′ 41.268″ and 4° 52′ 30.39″, and Longitudes 7° 07′ 26.695″ and 7° 07′ 45″ along the Aba-Port Harcourt Expressway in the Oyigbo Local Government Area.

This particular disposal is a built-up area with housing estates, schools, businesses and residential houses.

The area is characterized by tropical monsoon climate with lengthy and heavy rainy seasons and very short dry seasons. Only the months of December and January truly qualify as dry season months. The Harmattan, which climatically influences many cities in West Africa, is less pronounced in the area. The heaviest rainfall occurs during September with an average of 367 mm of rain. December on average is the driest month of the year; with an average rainfall of 20 mm. Temperatures throughout the year in the area are relatively constant, with average temperatures typically between 25 ºC - 28 ºC.

Fig. 1. A view of the Oyigbo Dumpsite

The composition of the wastes at Oyigbo dump site includes both degradable (paper wastes, food and agricultural wastes, sewage etc.) and non-biodegradable wastes (plastics, nylon, aluminum and other metal containing substances). The composition of solid wastes found in other cities includes papers and cartons, food remnants, glass and bottles, plastic and polythene, tin and metals, ashes and dust, textile and rags, aluminum and other minerals. Vegetation remains forms a large part of the most waste dump.

B. Research Design

Purposive sampling was used in data collection. The sampling was done during the rainy season in June, 2019. The pollutants of concern in the water samples included; toxic metals, pathogens and nutrients. In-situ measurements of pH and Temperature were done on freshly collected water samples. A total of three (3) boreholes were identified that covered the entire study area.

C. Sources of Data

Primary data were collected through direct field survey. The data were collected from water samples around the dumpsite situated in Oyigbo, within Oyigbo Local Government Area of Rivers State, Nigeria. Groundwater samples were collected from three boreholes in locations surrounding the dumpsites. Water samples were designated W1, W2, and W3. And were immediately taken to the department of Petroleum Engineering in Rivers State University, Nigeria for chemical, physical and heavy metals analyses. Analyses were carried out by the officials in the laboratory with the author in attendance and results were obtained for interpretation. The results obtained were compared with World Health Organization [16] and Nigerian Standard for Drinking Water Quality [17].

D. Analytical Techniques and Laboratory Analysis

The adopted methods of analyses for the examination of all parameters in potable and wastewater were in accordance with the procedure recommended in standard Methods for the examination of water [18] All samples were analyzed for selected physical, chemical and heavy metals parameters.

E. Parameters Examined

This study examined eighteen (18) Parameters of physical and chemical (including heavy metals) namely; pH, Turbidity, Odour, Colour, Temperature (ºC), Total Suspended Solid (TSS), Total hardness (TH), Total Dissolve Solids (TDS), Nitrate (NO^-_3), Dissolved Oxygen (DO), Sulphate (SO_3), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Chromium (Cr), Chloride (Cl), Iron (Fe), cadmium (Cd) and Lead (Pb). Analysis of the metals Pb, Fe, Cr, and Cd were done using atomic absorption spectrometer. Atomic Absorption spectrophotometer was used to determine the concentration of each heavy metal under specific wavelengths. The samples (100 ml each) were digested with 5ml of nitric acid (HNO_3) to liberate organic molecule from the samples, and heated at the temperature range of 45°C to 65°C before being taken to sensitive laboratory. Chemical parameters were detected through different titrations applicable to each variable.

III. RESULTS AND DISCUSSION

A. Results

The results of the physicochemical parameters of the selected boreholes are shown in Table 1. The values obtained are compared with World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) standards for drinking water.

B. DISCUSSION

Analysis of the physical properties of sampled groundwater (Table 1) shows that in all sample locations, Colour, Odour and Turbidity were in compliance with WHO and NSDWQ standards for drinking water. The pH ranged from 5.4-6.23.

Total Dissolve Solids, Total Hardness, Chloride, Sulphate, and Nitrate were in compliance with WHO standards. Chromium, Cadmium, lead, iron, COD, DO and BOD were above recommended standards.

Table 1. Physicochemical Parameters of Analyzed Groundwater Samples

Parameters	W1	W2	W3	WHO [16] Standard	NSDWQ [17] Max. permitted levels
Colour (hazen unit)	Colourless	Colourless	Colourless	5.0-15	15
Temperature (℃)	26.3	26.2	26.2	27-28	Ambient
Odour	Odourless	Odourless	Odourless	Odourless	Odourless
Turbidity (NTU)	0.011	0.011	0.011	5	5
pH	6.23	5.4	6.1	6.5-8.5	6.5-8.5
Total Hardness (mg/L)	7.00	5.00	1.50	500	150
TDS (mg/L)	55	5	10	500	500
Chloride (mg/L)	100	100	50	250	250
Nitrate (mg/L)	0.10	0.09	0.04	50	50
Sulphate (mg/L)	1.03	0.01	1.54	250	100
BOD (mg/L)	12.8	10.6	9.8	2.0	2
COD (mg/L)	153.57	171.37	162.56	NS	80
DO (mg/L)	10	8.2	7.1	2.0	100
Chromium (mg/L)	4.52	1.64	1.09	0.05	0.05

Iron (mg/L)	1.53	1.05	0.95	0.3	0.3
Lead (mg/l)	0.18	0.10	0.39	0.01	0.01
Cadmium (mg/L)	0.03	0.01	0.02	0.002	0.003

*NTU- nephelometric turbidity unit, *NS-Not Supplied

IV. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

The effect of open dumpsite leachate on groundwater quality has been examined using Oyigbo, Rivers State, Nigeria dumpsite as a case study. The results obtained for the groundwater sample were compared with World Health Organization and Nigeria Standards for drinking water quality. The study reveals that the concentration of waste materials in the dumpsite had systematically polluted the groundwater over time. The effect of such pollution as determined from the study declined away from the polluting source. This implied that the groundwater sources closer to the dumpsite are at higher risk of getting contaminated than those farther away from the dumpsite.

Eighteen (18) parameters were examined in relation to three water samples collected. It was discovered that Cadmium (Cd), chromium (Cr), lead (Pb), iron (Fe), COD, DO and BOD were above the WHO standard limit in all the samples. The Concentration of ions and chemical parameters such as chloride, sulphate, nitrate, total dissolve solids, total hardness and suspended solid were above the WHO standard limit. The pH of the groundwater samples did not meet the required standards.

As a result of the high levels of heavy metal contamination of the water from the boreholes, health problem such as carcinogenic, conjunctivitis or retinitis are imminent when such water is consumed. The dumping of industrial waste and heavy metals were considered the greatest hazard on the dumpsite from the study. When these chemical elements are absorbed by soils, the toxins can pass into the food chain through grazing animals.

B. Recommendations

Toward the control of groundwater vulnerability to pollution through landfills, the following are recommended:

i. There is need for adequate and proper planning, design and construction, and strategic management disposal of waste.
ii. Open dumping system need to be outlawed and provision of modern sanitary landfills should be provided to ameliorate and alleviate the incessant groundwater contamination.
iii. Government is to locate new landfills away from the general population to avoid contamination of their water supply.
iv. Modern waste management and treatment policy should be put in place for the landfill and waste disposal must be controlled by pre-treatment before disposal or after disposal.
v. There is also a need for public awareness about the specific purpose of which the groundwater in the study area can be used for and incase of domestic use, necessary purification methods should be applied for health safety.
vi. On- going assessment / monitoring of water quality from time to time, especially around Oyigbo Rivers State, Nigeria, together with the bacteriological assessment is encouraged to complement this study.

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