Effect of Domestic Waste Leachates on Quality Parameters of Groundwater

John Jiya MUSA

Department of Agricultural and Bio-resources Engineering, Federal University of Technology, P M B 65 Minna, Nigeria
Email: johnmusa125@rocketmail.com
Phone: +234(0)-809-4747-246

Abstract

Water is an elixir of life. Percolating groundwater provides a medium through which wastes particularly organics can undergo degradation into simpler substances through biochemical reactions involving dissolution, hydrolysis, oxidation and reduction processes. Ground water samples in and around dumpsite and landfills located in Kubuwa were studied to assess the effect of wastewater leachates on groundwater resources in the particular area. Groundwater samples were collected from 5 different bore-wells in and around relative distances from dumpsites. EC values ranged between 30 and 138 μS/cm, TDS ranged between 95 mg/L and 120 mg/L, SS ranged between 10 and 23 mg/L while that of the evening ranged between 11 and 15 mg/L, nitrate values ranged between 0.18 to 0.80 mg/L for the early morning samples while the late evening samples which ranged between 0.25 and 0.43 mg/L, while concentration of Sulphate in the morning water sample ranged between 168 and 213 mg/L while that of the evening ranged between 20 and 45 mg/L. The government of the Federal Republic of Nigeria should create landfills and dumpsites far away from residential homes and better still recycling plants should be put in place to recycle the various forms of waste products from homes.

Keywords

Groundwater; Water Pollution; Water Quality; Morning; Landfills

Introduction

In low-income countries, population growth coupled with urbanization has outpaced the development of sanitation infrastructure, leaving the urban poor, especially, virtually without sanitation facilities in many countries. About 2.4 billion people worldwide lack access to basic sanitation, 80% of them in Asia and 13% in Africa [1]. Although, sanitation coverage is better in urban than in rural areas, still more than 300 million urban residents lack sanitation facilities and the numbers are increasing. Only 60% of the total population has sanitation coverage, with coverage varying from 84% in urban areas to 45% in rural areas; and, in some countries [1].

Water is an elixir of life. It governs the evolution and function of the universe on the earth hence water 'mother of all living world'. Majority of water available on the earth is saline in nature; only small quantity is fresh water. Freshwater has become a scare commodity due to over exploitation and pollution. Pollution is caused when a change in the physical, chemical or biological condition in the environment harmfully affect quality of human life including other animals' life and plant. Industrial, sewage, municipal wastes are been continuously added to water bodies hence affect the physiochemical quality of water making them unfit for use of livestock and other organisms [2].

Access to safe clean water and adequate sanitation is a fundamental right and a condition for basic health [3]. However, in the developing world, one person in three lacks safe drinking water and sanitation. The lack of safe drinking water and adequate sanitation measures lead to a number of diseases such as cholera, dysentery, salmonellosis and typhoid, and every year millions of lives are claimed in developing countries. Diarrhea is the major cause for the death of more than 2 million people per year world-wide, mostly children under the age of five. It is a symptom of infection or the result of a combination of a variety of enteric pathogens [4]. Water-borne pathogens infect around 250 million people each year resulting in 10 to 20 million deaths world-wide [5]. This highlights the potential of infection due to water - borne pathogens.

However, within the urban areas there are disparities in the provision of some basic services such as electricity, potable water supply. Nevertheless, where population density is high, pollution may result because these are often located in close proximity with utilized water resources. The situation may be worsening by the hydrogeology of the area, which permit persistence, and mobility of the pollutants. Lack of solid waste disposal systems is also threatening water resources in urban areas [6].

There has been an increasing concern about the environment in which man lives. Solid wastes, mount of rubbish, garbage and sewage are being produced everyday by our urban society. In an attempt to dispose of these materials, man has carelessly polluted the environment. Some component of these wastes including food, paper, metals, polythene bags, zinc and lead containing materials etc consume oxygen thereby changing the redox potential of the liquid present [7].

The poor collection of waste in Kubwa urban areas leads to indiscriminate refuse dumping close to resident. In the peri-urban areas, domestic waste collection is not done at all. Thus, disposing of wastes can give rise to serious pollution of ground and surface water resources especially where there is uncontrolled tipping of waste. As such, lack of adequate sanitation facilities continues to threaten water resources in urban areas. Water supply systems and sanitation facilities are directly linked to behavioral practices in major cities around Nigeria most especially Kubwa a satellite town in the Federal Capital Territory, Abuja.

Percolating groundwater provides a medium through which wastes particularly organics can undergo degradation into simpler substances through biochemical reactions involving dissolution, hydrolysis, oxidation and reduction processes. This leachate, the liquid drains from the dump, mainly organic carbon largely in the form of fulvic acids migrate downward and contaminate the groundwater [7]. The natural aquatic resources are causing heavy and varied pollution in aquatic environment leading to water quality and depletion of aquatic biota. It is therefore necessary that the quality of drinking water should be checked at regular time interval because due to use of contaminated drinking water, human population suffers from a variety of water borne diseases [8].

The main objective of the study was to determine extent of water quality available to residents in Kubwa Township, and to see how domestic waste affects the quality parameters of ground and surface water sources in the area.

Material and Method

The study carried out in the Gwazango extension area in Kubwa of the Federal Capital

Territory (FCT) Abuja, Nigeria which lies within the savannah region on latitude 8°25’N and 9°20’N and longitude 6°45’E and 7°39’E of Greenwich meridian. Kubwa is located along Zuba-Wuse express way.

The survey on the quality of ground water samples was conducted between April and June 2011. Water samples were collected from each of the five bore-hole sites into a 1 liter plastic container each at stipulated times. The plastic containers were cleaned using 1 mol/L of nitric acid. They were then left to dry for 2 days followed by thorough rinsing with distilled water. Standard procedures were followed as stated by Musa *et al.* [18]. The bore-hole were identified and labeled as BH0, BH1, BH2, BH3, BH4 and BH5 respectively. These labeling were used also for the plastic containers. Water samples were collected using 75 CL treated plastic containers. At the point of sampling, the containers were also rinsed using the ground water respectively several times before the respective samples were taken. The samples collected at the early hours of the day were separately from those of late hours and where transported to the Federal Ministry of Water Resources Laboratory in Minna in an iced box at a temperature of about 4°C prior to the analysis [9, 10]. An average of ten samples of each set (morning at 6 AM and in the evening at 18 PM) were collected and analyzed from each of the borehole. The groundwater samples were analyzed for physical and chemical parameters according to APHA [9].

The physical parameters analyzed include Total dissolved solid (mg/L), temperature (°C), suspended solid (mg/L), turbidity (NTU), colour (pt. co), while the chemical parameters includes electrical conductivity (μs/cm), pH, iron content (mg/L), sulphate (mg/L), nitrate as nitrogen (mg/L), nitrate (mg/L), total hardness (mg/L), hardness (Ca), hardness (Mg), total alkalinity (mg/L) and phosphate as phosphorus (mg/L). The samples for trace metal analysis were acidified with concentration HNO_3 to bring the pH < 2. Sample Collection, preservation and analysis were done as per the standard methods of APHA [9].

Results

Five existing 6” diameter boreholes with average depth of 40 meters in basement formation located within the distance 50m, 80m and 100m radially away from the center of the landfill were used as sampling points for groundwater quality testing. Data on parameters considered from the study area for both morning and evening water samples from ground water located within proxy distances to the five bore holes are presented in Table 1 and 2 respectively.

Table 1. Physicochemical Parameters of Morning ground Water samples

S/N	Parameters	BH1	BH2	BH3	BH4	BH5	NSDWQ
1	Electrical conductivity (µS/cm)	130	30	128	114	138	1000
2	Total dissolved solids (mg/L)	65	132	109	73	98	500
3	Temperature in the laboratory ($^{\circ}$C)	26.2	26.2	26.5	26.2	26.8	Ambient
4	Suspended solids (mg/L)	10	17	15	18	23	25
5	Turbidity (NTU)	9	5	3	4	6	5
6	Colour (pt.co)	37	5	12	18	14	N/S
7	pH	6.8	6.8	7.2	7.1	6.9	6.5-8.5
8	Iron content (mg/L)	0	0.06	0.32	0.3	0.2	0.3
9	Sulphate (mg/L)	231	187	204	168	174	400
10	Nitrate as nitrogen (mg/L)	3.6	5.8	7	5	8	10
11	Nitrate (mg/L)	0.6	0.8	0.3	0.18	0.24	0.2
12	Total hardness (mg/L)	58	69	69	74	80	100
13	Hardness (ca) $CaCO_3$	23.2	22.3	20.5	19.4	25.6	N/S
14	Hardness (mg) $CaCO_3$	34.8	36.6	28.7	38.5	31.6	N/S
15	Total alkalinity (mg/L)	73	69	74	60	59	100
16	Phosphate as phosphorus (mg/L)	0.03	0.01	0.23	0.18	0.16	N/S

Table 2. Physicochemical Parameters of Evening ground Water samples

S/N	PARAMETERS	BH1	BH2	BH3	BH4	BH5	NSDWQ
1	Electrical conductivity (µS/cm)	190	202	196	213	211	1000
2	Total dissolved solids (mg/L)	95	104	118	112	120	500
3	Temperature ($^{\circ}$C)	27.9	28.4	28.2	27.8	27.9	Ambient
4	Suspended solids (mg/L)	21	35	31	23	25	25
5	Turbidity (NTU)	1	2	1	3	1	5
6	Colour (pt.co)	10	10	9	6	8	N/S
7	pH	6.8	7.1	6.9	6.8	7.2	6.5-8.5
8	Iron content (mg/L)	0.13	0.2	0.14	0.15	0.2	0.3
9	Sulphate (mg/l)	23	20	35	45	32	400
10	Nitrate as nitrogen (mg/L)	5.9	6.5	6.1	5.4	7.2	10
11	Nitrate (mg/L)	25.96	38.65	41.5	43.23	27.68	0.2
12	Total hardness (mg/L)	76	79	63	52	59	100
13	Hardness (ca) $CaCO_3$	30.4	31.8	31.3	30.6	31.6	N/S
14	Hardness (mg) $CaCO_3$	45.6	45.8	48.67	38.75	35.57	N/S
15	Total alkalinity (mg/L)	4	38	24	45	38	100
16	Phosphate as phosphorus (mg/L)	0.01	0.02	0.11	0.15	0.13	N/S

NSDWQ means Nigerian Standard for Drinking water quality

Discussion

It can be observed from Table 1 that the electric conductivity values obtained from the various samples at the early hours of day ranged between 30 and 138 µS/cm with the highest observed at BH5 while the lowest value was obtained at BH2. These values are within the standard range of 1000 µS/cm set by NSDWQ [11]. The low values indicate the low effect of landfill and wastewater respectively. Zektser et al. [5] mentioned that, EC is a valuable indicator of the amount of material dissolved in water whereas Sophocleous [12] mentioned that, the high values of EC can be attributed to the high levels of the various anions.

The Total Dissolved Solids (TDS) ranged between 65 mg/L and 132 mg/L for the early morning samples while that of the late evening ranged between 95 mg/L and 120 mg/L. it can be observed from the results of BH1 for the morning samples had a lower value of TDS as against that of the evening of 95 mg/L. this may be attributed to the fact that no pumping of water from the said bore took place from the late evening when the borehole pumping machine was locked thus allowing the water to settle. The results of BH2 for the early morning were observed to be higher than that obtained from the evening which may be attributed to the proximity of the borehole to the residential areas where septic tanks are evident. These results were compared with NSDWQ [11] and where found to be within the permissible limit of the 500 mg/L. This is in conformity with the work of Osibanjo [13].

The samples were generally collected between April and June which usually marks the end of the dry season and the start of the rainy season in the north central area of Nigeria; thus influencing the temperature of the environment. The temperature of the early hours ranged between 26.2 and 26.8°C while that of the evening ranged between 27.9 and 28.4°C. The temperature during the study period remained uniform through very minor differences can be observed.

The suspended solids (SS) for the early morning samples ranged between 10 and 23 mg/L while that of the evening ranged between 11 and 15 mg/L. this difference may be noticed as a result of the non-usage of the bore holes as from late evening to the early hours of the morning when the bore holes are opened for use by the community. The two sets of results are within the standard of NSDWQ [11].

Turbidity is the degree to which water loses its transparency due to the presence of suspended particulates. From the result obtained, it can be observed that the turbidity of the various water samples collected in the early morning and late evening hours were not uniform. The results show that the early morning hours had values ranging between 1 and 4 NTU while that of the evening hours ranged between 1 and 3 NTU. The samples were observed to have clear natural colour during the study period which is in conformity with the work of Palamuleni [14]. The results also show that the values obtained were within the standards of NSDWQ [11].

The pH values of the five boreholes were samples were collected from was found to range between 6.8 and 7.2. When these results were compared with the set standard of NSDWQ [11], they were observed to be within the range. The highest value of pH was recorded at BH3 for that of the early hour sample while that of the evening was BH5. This lessens the ability of the water to contain metal ions and therefore does not pose any health risk to the consumers. This result is in conformity with the work of Bozkurt [15]. There is a general consensus that the lower pH cluster represents the acid producing phase and the upper cluster represents the methanogenic phase. During the initial stage the pH values are quite low, while during the methanogenic stage the pH appeared to be neutral to alkaline.

The nitrate values of most of the sampled water were found to be above the stipulated limit of 0.20 mg/L by NSDWQ [11]. They range from 0.18 to 0.80 mg/L for the early morning samples while the late evening samples which ranged between 0.25 and 0.43 mg/L were found to be above the limit [11]. Nitrate, the most highly oxidized form of nitrogen compound is commonly present in surface and groundwater because it is the end product of the aerobic decomposition of organic nitrogenous matter. Unpolluted natural waters usually contain only minute quantities of nitrate. Nitrates and nitrites had their values ranging from 3.6 to 8 mg/L for the early morning samples while that of the late evening values ranges between 5.4 and 7.2 mg/L respectively showing appreciable presence of pollutants in all the water samples but still within the recommended values of [11]. Nitrites are relatively short-lived because they are quickly converted into nitrates by bacteria which exist in the air. Nitrites react directly with hemoglobin in human blood to produce methemoglobin, which destroys the ability of blood cells to transport oxygen [16].

Agbalagba [17] stated that the World Health Organization (WHO) International Standard for Drinking Water in 1998 classified water with a total hardness of $CaCO_3 < 50$ mg/L as soft water, 50 to 150 mg/L as moderately hard water and water hardness above. Based on this classifications, all the water samples analyzed for morning samples were within the limits [11] as the values found to be below the recommended value 100 mg/L thus they are classified as soft water while the samples for evening ranged between 52 and 79 mg/L which was also below the recommended value [11], thus the waters are suitable for domestic use in terms of hardness. This is because moderately hard water is preferred to soft water for drinking purposes as hard water is associated with low death rate from heart diseases. Values above 200 mg/l for total hardness (TH) do not have any associated adverse health-related effects on humans but is an indication of deposits of Ca and/or Mg ions. Their presence will disallow water from forming lathe with soap thereby preventing economic management of water resources [10, 16, 18].

The addition of phosphorus as phosphate ion, to natural waters is one of the most common environmental problems because of its contribution to the eutrophication process. The values for the morning samples ranged between 0.01 and 0.23 mg/L while that of the evening ranged between 0.01 and 0.15 mg/L. Though, the NSDWQ [11] did not give any range of value for this parameter.

The recorded values of the dissolved and total iron content were found to be relatively high in the early morning samples with the values ranging between 0.00 and 0.32 mg/L with BH3 slightly exceeding the recommended value of 0.30 mg/L of NSDWQ [11]. The values of the samples obtained during the evening hours ranged between 0.13 and 0.2 mg/L. The evening hour sampled values were observed to be lower when compared with the recommended value of NSDWQ [11]. This can impact an unpleasant ironish smell to drinking water and a bittersweet taste can be detected at level above 1-2 mg/L. Consequently, the parameter does give concern as it renders the water unsuitable for domestic use.

The concentration of sulphate in the morning water sample ranged between 168 and 213 mg/L while that of the evening ranged between 20 and 45 mg/L. The sharp reduction in the determined values was noticed because of the consistency in the high rate withdrawer of water during the day time. Though the determined values were within the recommended values of NSDWQ [11] of 400 mg/L thus it will adversely not affect the use of this water bodies for domestic purposes.

The total alkalinity concentration of the early morning samples ranged between 59 and 74 mg/L while that of late evening ranged between 4 and 38 mg/L. It was observed that the values for the samples collected in the evening were far below that of the early hours of the day. The values obtained for the two periods did not exceed the maximum permissible value of NSDWQ [11].

In Nigeria today, the use of ground water has become an agent of development because the government is unable to meet the ever increasing water demand. Thus, inhabitants have had to look for alternative water sources such as shallow wells and boreholes. The quality of these ground water sources are affected by the characteristics of the media through which the water passes on its way to the groundwater zone of saturation, thus, the heavy metals discharged by industries, traffic, municipal wastes, hazardous waste sites as well as from fertilizers for agricultural purposes and accidental oil spillages from tankers can result in a steady rise in contamination of ground water.

Conclusions

Considering the nature and geology of the study area which is predominantly sandy loam and clay soils, dumpsites must be located on a geologically impermeable ground like clay. Thus preventing or limiting the downward movement of various chemical properties into the various groundwater bodies in residential areas. It is therefore concluded that water from the various study locations are fit for domestic consumptions as the samples studied did not indicate any adverse or extremely high chemical content that may affect the health of those consuming the water.

References

1. Keraita B., Drechsel P., Amoah P., *Influence of urban wastewater on stream water quality and agriculture in and around Kumasi, Ghana*, Environment and Urbanization, 2003, 25(1), p. 171-178.
2. Muhibbu-Din O. I., Aduwo A. O, Adedeji A. A., *Study of Physiochemical Parameter of Effluent Impacted Stream at Obafemi Awolowo University Ile-Ife, Nigeria*, A Dissertation Submitted to the Department of Zoology, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria. 2011 (unpublished).

3. United States Environmental Protection Agency (EPA), Washington, DC. "The National Water Quality Inventory: Report to Congress for the 2002 Reporting Cycle – A Profile." 2007. Fact Sheet No. EPA 841-F-07-003.

4. ANON., Rural water sources under the microscope, SA Water bulletin, 2000, 26(3), p. 18-21.

5. Zektser S, Loaiciga H. A., Wolf J. T., *Environmental impacts of groundwater overdraft: selected case studies in the southwestern United States*, Environmental Geology, 2005, 47(3), p. 396-404.

6. Odukoya O. V., Arowolo T., Bamgbose O., *Effects of solid waste Landfall on underground and surface water quality at ring road, Ibadan, Nigeria*, Global Journal of Environmental Sciences, 2002, 1(1), p. 43-52.

7. Ugwu S. A.; Nwosu J. I., *Effect of Waste Dumps on Groundwater in Choba using Geophysical Method*, Journal of Applied Sciences and Environmental Management, 2009, 13(1), p. 85-89.

8. Raman N., Sathiyanarayanan D., *Quality Assessment of Ground Water in Pallavapuram Municipal Solid Waste Dumpsite Area Nearer to Pallavaram in Chennai, Tamilnadu. RASAYAN*, Journal of Chemistry, 2011, 4(2), p. 481-487.

9. American Public Health Association (APHA). American Water works Association and Water Pollution Control Federation, Standard Method for Examination of Water and Wastewater, APHA, AWWA and WPCF, 2005, (46), New York.

10. Akudo E. O., Ozulu G. O., Osogbue L. C., *Quality assessment of groundwater in selected dump sites areas in Warri, Nigeria*, Environmental Research Journal, 2010, 4 (4), p. 281-285.

11. NSDWQ, Nigerian Standards for Drinking Water Quality, 2007, ICS 13.060.20.

12. Sophocleous M., *Interactions between groundwater and surface water: the state of the science*, Hydrogeology Journal, 2002, 10(1), p. 52-67

13. Osibanjo O., Adie G. U., *Impact of effluent from Bodija abattoir on the physico-chemical parameters of Oshunkaye stream in Ibadan City, Nigeria*, African Journal of Biotechnology, 2007, 6(15), p.1806-1811.

14. Palamuleni L. G., *Effect of sanitation facilities, domestic solid waste disposal and hygiene practices on water quality in Malawi's urban poor areas: a case study of South Lunzu Township in the city of Blantyre*, Physics and Chemistry of the Earth, Parts A/B/C, 2002, 27(11-22), p. 845-850.

15. Bozkurt A., Kurtulus C., *Groundwater quality in Korfez Municipality (Kocaeli), northwest of Turkey*, Journal of Food, Agriculture and Environment, 2008, 6(3&4), p. 551-553.

16. Akinbile C. O., Yusoff M. S., *Environmental Impact of Leachate Pollution on Groundwater Supplies in Akure, Nigeria*, International Journal of Environmental Science and Development, 2011, 2(1), p. 81-86.

17. Agbalagba O. E., Agbalagba O. H., Ononugbo C. P., Alao A. A., *Investigation into the physico-chemical properties and hydrochemical processes of groundwater from commercial boreholes In Yenagoa, Bayelsa State, Nigeria*, African Journal of Environmental Science and Technology, 2011, 5(7), p. 473-481.

18. Musa J. J., Adewumi J. K., Adeoye P. A., Mustapha I. H., Adebayo E. S., *Physicochemical Assessment of Groundwater as a Source of Domestic Water Use in Some Selected Settlements in Minna, Niger State*, IUP Journal of Science & Technology, 2011, 7(2), p.35-44.

19. Onwughara N. I., Umeobika U. C., Obianuko P. C., Iloamaeke I. M., *Emphasis on Effects of Storm Runoff in Mobilizing the Heavy Metals from Leachate on Waste Deposit to Contaminate Nigerian Waters: Improved Water Quality Standards*, International Journal of Environmental Science and Development, 2011, 2(1), p. 55-63.