Assessment of Groundwater Quality at a Waste Disposal Site of Ranji Waste Disposal Site in Bampai Industrial Area Kano-Nigeria

A. S. Aliyu

Department of Civil Engineering, Kano University of Science and Technology, Wudil Kano, Nigeria

Abstract: ***The groundwater quality at Ranji waste disposal site is threatened by contamination. the presence of some harmful organic like phenols and phosphate and inorganic substances like n itrites, cadmium ,lead, chromium were established in the leachate, bore hole samples were collected in the area and also analyzed for the same substances but only lead was found to be present.***

Keywords: water quality, groundwater, waste disposal, natural reservoir, pollution, pollutants

1. Introduction

Groundwater being one of the vast natural resources on the earth is known to occur more widely than surface water the ratio of surface to groundwater was put at 1:33 (Bouwer, 1978). Groundwater is a very good source of drinking water, because of the purification properties of the soils; it is also used for irrigation and spraying, and where surface water is scarce, for industrial purposes. In many arid and semi-arid zones, it is the main source of water. An aquifer constitutes a natural reservoir of usually high – quality water. Although it is more protected than surface waters, groundwater appears to be subject to pollution, a phenomenon that can be defined as a modification of the physical, chemical and biological properties of water, restricting or preventing its use from the various applications where it normally plays a part.

The pollution of this natural resource may be direct or indirect, direct groundwater pollution may result from the location of disposal pits, ponds or industrial / municipal waste disposal points above or direct into an unconfined aquifer system, such liquid wastes or leachate infiltrate into the aquifer. The flow pattern of leachate may be complicated by the occurrence of aquifers with undifferentiated sediments of varying permeability, other factors that affect the flow includes the saturated thickness, hydraulic gradient of aquifers sometimes associated with groundwater flow barriers and recharge boundaries including rainfall variations which affect groundwater regime (Urish,1983).

Bompai industrial area was designed and established since the colonial era as properly planned industrial area, but due to recent increase in population, urbanization and its close proximity to urban Kano, the area have come to be surrounded by complicating land uses which comprises of residential housing units, educational and commercial institutes, leading to inadequacy of potable water and other essential services like solid waste disposal. It was identified that essential services such as water supply and waste disposal are below adequate standard, and the current actual water supply to city is believed to be in the order of 150 ml/day, so the water supply scheme currently supplies only 50% of the capacity (Parkman, 2000). The inadequate supply of potable water to this area has caused over reliance in the use of an alternative source of water, which is the groundwater and the quality of groundwater has become questionable, due to the fact that most of the boreholes that sell water to the residents are located in the industries, which burry their waste. (Dakata, F.A 2002).

2. Types of Ground Water Pollution

Water is polluted when any substances or materials or activities change the quality of natural water to such a degree that it is neither fit for human consumption nor support of man's natural life process. Water pollution, therefore can be referred to as degradation of water quality as measured by biological, chemical and physical criteria.

3. Biological Contamination

Biological contamination is generally due to the introduction of organic waste material in to the aquifer system e.g. are bacteria which are responsible for different kinds of diseases, such as cholera, dysentery, diahorrea, gastroenteritis, typhoid among others. Some undesirable characteristics can also be caused such as tastes and odours, corrosion and encrustation in borehole delivery pipes. Bacteria are known to survive under very difficult biological conditions. And the two most predominant types of bacteria that appear in ground water are the coli forms, Escherichia coli (E – coli) and faecal streptococci these coli forms bacteria are not harmful to humans, but are known to live in the intestine of human beings and other warm – blooded animals. They are associated with fresh human and animal excreta, a potential source of disease causing bacteria and viruses. Therefore, coli forms bacteria and their associates live on the ground surface and in area exposed to sewage disposal, dumping of human and other animal faeces.

Different researches and experiments conducted in this field show that bacteria do not thrive easily under subsurface conditions. Most bacteria and other biological contaminants would be removed during percolation of bacteria from the ground depends on the permeability. As such coli forms bacteria can be found in shallow wells with high water tables or wells very close to sewage tanks, pit latrines and other sources of pollution with which it maintains hydrological contact.

In deep boreholes sustained from open fractures and solution channels through which recharge from surface sources can occur, bacteria pollution is possible. But in deep well protected boreholes, harmful group of bacteria can only be introduced during drilling which can be protected only by disinfection.

Iron bacteria's are known to be harmless to human but causes encrustation borehole and are found in geological environments with high irons content. They are thought to feed on carbon compounds including bicarbonates and carbon dioxide. During their life cycle, the iron is changed into insoluble oxides, which form slimy substances. This slimy substance can trap other particles or materials from the ground to form deposits or encrustation on the screens in boreholes, which causes blockage of the screens.

Opening and subsequent reduction in the flow of water into boreholes, such bacteria effect creates a serious problem in borehole industry.

In general, water bearing sand functions provides effective mechanical straining for bacteria and therefore cannot reach deep aquifer. However, at the completion of any borehole adequate biological analysis should be carried out periodically as a check for possible biological contaminations.

4. Chemical Contamination

Chemical contamination in groundwater results from the introduction into the reservoir through natural or manmade activity, of organic or inorganic elements. These elements affects the quality of ground water by either increasing or decreasing the acidity of the water, the Oxidation Reduction Potential (ORP) increasing hardness, organic Nitrogen, chloride and other offensive organic and inorganic materials.

Inorganic contaminant includes chemicals like Arsenic, Nitrates, Fluorides, and selenium, Barium and metals like chromium, cadmium, mercury, lead and silver. Other inorganic constituents can be grouped as Total Dissolved Solids (TDS), sulphate, iron and manganese. The organic contaminants comprise volatile organic compounds, pesticides and herbicides and other non-volatile compounds, and radiological constituents like uranium and Radium etc.

The concentration of organic contaminants in groundwater depends on the solubility of the contaminants. These substances are carried and transported as ions, molecules and colloids organic acids, base and salts form solution in water, while substances like sugar, alcohols and intro-phenols are easily dissolved in water as molecules. Other chlorinated hydrocarbons have low solubility.

The chemical composition of recent discoveries of numerous toxic chemicals in well water has changed the belief that solid waste (domestic and industrial) is safe and can be disposed off indiscriminately. Research showed that among the organic and inorganic chemicals mentioned above cause's different types of diseases in humans (Montgomery, 2000).

The world Health organisation has set standards that are acceptable for potable water for all these constituents.

5. Physical Contamination

Physical contamination of groundwater may be due to following factors temperature, taste and odour, colour turbidity, solid materials, electrical conductivity as described below.

- **Temperature:** - This factor affects other properties of groundwater contamination, because high temperature increases the speed of chemical reactions, reduction of gas solubility and emission of unpleasant odour and tastes. It also enhances corrosion and encrustation in boreholes and pipelines.
- **Taste and odour:** - The high level of dissolved organic and inorganic matter like phenols and dichloro- phenols, iron, and salt cause unpleasant odour and taste in groundwater. Offensive odours can cause poor taste of food, lowered water consumption, impaired respiration, nausea, and vomiting and mental perturbation.
- **Colour and Turbidity:** - Natural pure water is supposed to be colourless, Groundwater, however assumes some colours usually due to dissolved substances e.g. brownish colour may be due to iron. The high concentration of colloidal materials like clay and silt gives a cloudy appearance in some ground waters, though some of these materials may be indicative of some type of pollution.

6. Methodology

The methods employed in testing the samples; are potable parameters, spectrophotometer and titration. The analysis of parameters was grouped as follows;

Physical Characteristics

- Temperature
- Colour
- Odour
- Turbidity
- Conductivity

Chemical Characteristics

- pH
- Alkalinity
- Hardness
- Calcium
- Magnesium
- Chloride
- Biological Oxygen Demand (B O D)

Inorganic Substances

The following inorganic substances that are of health significance were analysed:

- Lead
- Cadmium and chromium (total)

3.2 Sampling Method

The method of sampling used was grab sampling which allows for collection of sample at a particular time and place.

3.3 Sampling Point

Samples used for analysis were collected from three boreholes that are located within Ranji waste disposal site, which are Reza plastic and block industry, Arewa tannery and Gezawa plastic industry.

3.4 Samples were also collected from pond around the ditch for analysis.

7. Result and Analysis

Water samples were collected from three different monitoring boreholes located at Northern part of the disposal site, where the waste is most concentrated; also a sample of surface water in a pond at the dump site was analyzed Inorganic substances FEPA guidelines for groundwater protection and WHO water quality standards were used to compare the results obtained from analysis of water from three different boreholes and surface water Ranji dumpsite.

8. Physical Characteristics

pH – The PH value obtained for the three samples from Gezawa plastic, Arewa tannery and Reza plastics was 6.0 respectively which is within the permissible limit set by FEPA. But the surface water has a PH of 7.4, which is slightly higher than that of the boreholes but also within the permissible limit.

TURBIDITY- the turbidity of water from Gezawa plastic was 2 NTU, Arewa 5 NTU and Reza 4 NTU, and all are within limit set by FEPA, except for the surface, which was 147 NTU and could be attributed to the presence of organic substances in the water.

Conductivity - Natural water has low conductivity, but the presence of concentration or dissolved substances increases it.

The conductivity of the three samples analysed was 350µs/cm, and FEPA has no limit for it, but the United Kingdom Regulations has it as 1500 µs/cm at 20^{o}c, while for the surface water the conductivity was very high 1,100 µs/cm, which could be attributed to the presence of dissolved (substances) solids, which could infiltrate in to the groundwater system.

TOTAL DISSOLVED SALT (TDS**)** - TDS = 0.7 X CONDUCTIVITY micros/cm.

Conductivity for all borehole samples = 350µs/cm, then TDS = 0.7X 350 = 245 mg/l

Surface water = 1,100 µs/cm, TDS = 0.7X 1100 = 770mg/l

HARDNESS **–** Hardness is a physical characteristic that is undesirable in excess and the harder the groundwater, the more its conductivity and the lower the resistivity.

Gezawa Plastics had 125.7 mg/l, Arewa tannery 219.9 mg/l and Reza Plastic 173.8mg/l, and comparing with WHO standards of 100mg/l implies the water is hard and can reduce the value of resistivity. And for the surface water with 336 mg/l could be attributed to dissolved solids.

FREE CO_2 **–** Free carbon dioxide in water depends on the alkalinity and pH of water; it is of much importance as regards to the corrosive properties of water. Some ground waters from deep boreholes may contain more than 100mg/l, but results from the analysis conducted on three water samples indicated that all are within the permissible limit set by WHO as that of Gezawa plastic was 36mg/l, Arewa tannery was 58mg/l and Reza was 60mg/l.While the surface water has 82mg/l which is also within the limit set by WHO.

Chloride - Chlorides are present in nearly all waters, but most combination is with sodium chloride, also may derive from natural mineral deposits e.g. seawaters, lakes e.t.c. Most rivers and lakes have chloride less than 50mg/l and any marked increase may indicate sewage pollution. The WHO standard for chlorine is 250mg/l and results obtained from the Gezawa Plastics, Arewa tannery, Reza Plastics and Surface water analysed are 136.2mg/l,177.7mg/l, 160mg/l and 141mg/l respectively, and when compared with the WHO standard all are within the permissible limit.

Calcium - Calcium is found in most waters and the level depends on the type of rock through which the water passed. There is no health objection to high calcium content in water and the main limitations being on the grounds of excessive formation of scale. The F.E.P.A gave the limit as 200mg/l while the results obtained are 43.3mg/l,63.1mg/l,53.2mg/l and 90mg/l for the 3 boreholes and the surface water respectively and all are within the permissible limit set y F.E.P.A.

Magnesium –Magnesium is also one of the earth's most common elements and forms highly soluble salts. Excessive concentrations of magnesium are undesirable in domestic water because of problem of scale formation. The limit set by FEPA IS 50mg/l and the results obtained are 4.4mg/l for Gezawa plastics, 15.3mg/l for Arewa tannery, 9.8mg/lReza plastics and 76.7mg/l for the surface water, all the borehole results were within the limit set by FEPA while the surface water has excessive magnesium above the FEPA limit.

Alkalinity – Alkalinity principally comprises the sum of bicarbonates, carbonates and hydroxides of calcium, magnesium, sodium and potassium .If alkalinity is less than total hardness, the excess hardness is permanent hardness and where the alkalinity is more than the total hardness, the excess alkalinity is due to the presence of sodium bicarbonate which does not affect the hardness no limit WHO or FEPA limit for alkalinity but is a key in determining the corrosive nature of water.

The results for the three boreholes are 45mg/l/60mg/l/and55mg/respectively and when compared with their respective results for hardness which are higher indicates that the water has permanent hardness. While the surface water has alkalinity of 490mg/l and comparing with the hardness of 336.7 mg/l shows that the water has no permanent hardness.

Color – Color in unpolluted water is caused by colored organic acid derived from peat and soil humus, in some waters it is enhanced by the presence of iron and manganese. Waters subject to industrial pollution can also contain a wide variety of colored material, the level at which color become unacceptable depends largely upon that which consumers are accustomed. The WHO standard for color is 7 Hazen and the result obtained for the three boreholes is 5 Hazen which is acceptable while the result for the surface water is 25 Hazen which is not acceptable.

Odor – Odors are caused by natural contamination such as extracellular and decomposition products of plants, algae and micro fungi .Water contamination resulting from agricultural and industrial discharges may lead to severe odor problems, the odor for the three boreholes is un objectionable while the surface water has objectionable odor.

Biochemical Oxygen Demand (B.O.D) – The B.O.D test gives an indication of oxygen required to degrade biochemically any organic matter in a water as well as the oxygen needed to oxidize inorganic material such as sulphates.

Inorganic Substances

Inorganic substances that are of health significance were analysed with regard to the type of wastes dumped at ranji being from tannery, soap, plastic and domestic.

Cadmium – for all the samples analysed there was no trace of cadmium found.

Chromium – all the samples were analysed for chromium total and no trace found.

Lead – There was no trace of lead found in the sample of surface water analysed, but Gezawa tannery had 0.0015mg/l, Arewa had 0.0017mg/l and Reza0.0015mg/l which could be attributed to the casing used for the boreholes

Table 4.1: Comparison between Result Obtained and WHO Standard Gezawa Plastic Borehole. (Units are in mg/l)

Parameter	*Result*	*WHO Standard*
Temperature	26	30
Ph	6	7.0-8.5
Color(hazen)	5	7
Odor	Un-objectionable	
Turbidity (NTU)	2	15
Conductivity(μs/cm)	350	250
Alkalinity(P)	0	
Alkalinity (M)	45	
Hardness	125.7	60
Calcium	43.3	200(FEPA)
Magnesium	4.4	50
Chloride	136.2	250
BOD	36	0
Lead	0.0016	0.001
Cadmium	Nil	0.001
Chromium	Nil	0.001
Free(CO_2)	36	100Mg/l
Coliform	Nil	400MPN/100 ml(FEPA)
E-Coli		

P-Phenolphthalein, M-methyl orange

Table 4.2: Comparison between Result Obtained and WHO Standard Arewa Tannery Borehole (Units are in mg/l)

Parameter	*Result*	*WHO Standard*
Temperature	26	30
Ph	6	7.0-8.5
Color	5(hazen)	7
Odor	Unobjectionable	
Turbidity (NTU)	5	15
Conductivity(μs/cm)	350	2250
Alkalinity(P)	0	
Alkalinity (M)	60	
Hardness	219.9	60
Calcium	63.1	200(FEPA)
Magnesium	15.3	50
Chloride	177.7	250
BOD	33.0	0
Lead	0.0017	0.001
Cadmium	Nil	0.001
Chromium	Nil	0.001
Free(CO_2)	58	100mg/l
Coliform	Nil	400MPN/100 ml(FEPA)
E-Coli	-	-

P-Phenolphthalein, M-methyl orange

Table 4.3: Comparison between Result Obtained and WHO Standard Reza Plastic and Block Industry Borehole. (Units are in mg/l)

Parameter	*Result*	*WHO Standard*
Temperature	26	30
Ph	6	7.0-8.5
Color	5(hazen)	7
Odor	Unobjectionable	
Turbidity (NTU)	3.5	15
Conductivity(μs/cm)	365	2250
Alkalinity(P)	0	
Alkalinity (M)	55	
Hardness	172.8	60
Calcium	53.2	200(FEPA)

Magnesium	9.8	50
Chloride	160.0	250
BOD	35	
Lead	0.0015	0.001
Cadmium	Nil	0.001
Chromium	Nil	0.001
Free(CO_2)	60	100Mg/l
Coliform	Nil	400MPN/100 ml(FEPA)
E-Coli	-	-

P-Phenolphthalein, M-methyl orange

Table 4.4: Comparison between Result Obtained and WHO Standard Surface Water. (Units are in mg/l)

Parameter	*Result*	*WHO Standard*
Temperature	28	30
PH	7.4	7.0-8.5
Color	25(hazen)	7
Odor	Objectionable	
Turbidity (NTU)	147	15
Conductivity(µs/cm)	1,100	2250
Alkalinity(P)	115.0	
Alkalinity (M)	490.0	
Hardness	336.7	60
Calcium	90	200(FEPA)
Magnesium	76.7	50
Chloride	141.1	250
BOD	38.0	0
Lead	Nil	0.001
Cadmium	Nil	0.001
Chromium	Nil	0.001
Free(CO_2)	82.0	100Mg/l
Coliform	18	400MPN/100 ml(FEPA)
E-Coli	18	-

P-Phenolphthalein, M-methyl orange

Table 4.5: Results of Surface Water Sample

Parameter (mg/l) / Sample	Sample Point	Sample Point
	NORTH	EAST
Nitrite	100 mg/l	110 mg/l
Phenol	0.93 mg/l	0.73 mg/l
Phosphate	47 mg/l	49 mg/l
Cadmium	0.9 mg/l	0.7 mg/l
Chromium	2.5 mg/l	0.2 mg/l
Lead	2.1 mg/l	1.7 mg/l
Chloride	150 mg/l	550 mg/l
Alkalinity	200 mg/l	192 mg/l
Ph	7.78	7.73 mg/l

9. Conclusion and Recommendation

5.1 Conclusion

The quality of groundwater at ranji is susceptible to contamination due to the practice of improper disposal of waste in the area, the inadequate supply of potale water has also caused the over reliance in the use of groundwater (boreholes). The areas in which these boreholes are located are mostly in the industries that are close to the dumping site. This research assessed the groundwater quality of the groundwater for any possible contamination from the leaching of waste. Pond sample was collected and analysed for the presence of harmful organic and inorganic substances like, lead, cadmium, chromium, nitrites, phenols and phosphates respectively to establish control for borehole samples. From the analysis of the borehole samples only the presence of lead was established for all the three samples of water used in the analysis other physical and chemical characteristics were also analysed for the borehole samples and comparison was made with WHO standard and all parameter are within the acceptable range.

5.2 Recommendation

Continuous groundwater quality control should be established in the area to avoid contamination.

Government to build a proper sanitary landfill in the area for proper utilization of the resources form waste being generated.

References

[1] Bouwer, H. (1978), Ground water Hydrology, New york, McGraw Hill.
[2] Dakata, F.A. (2002), Solid Waste disposal and Management at Bompai Industrial area of Kano State Unpublished B.Eng Thesis, Department of Geography, B.U.K
[3] Environmental Protection Agency (EPA) United States. (1993), Use of Airborne and Surface Geophysical Techniques at Contaminated Sites. Reference Guide EPA/625/R-92/007. .
[4] Lapai, G.Y. (1992), The Impact of Industrial Waste-water Discharges on the Health and Environment .A case study of Bompai, Challawa and Sharada Industrial areas of Kano, Unpublished B.Eng Thesis, Department of Civil Engineering B.U.K.
[5] Parkman. (2000), National Water Rehabilitation Project, (Greater Kano water Supply seasibility study) Rural Volume 3 Technical Appendices G – K P. 2 – 6 Parkman, Kaduna.
[6] Urish, D.W. (1983), The Practical Application of Surface Electrical Resistivity to Detection of Groundwater Pollution, Vol 21