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Assessment of the Level of Groundwater Contamination and Its Implications in Oil Pipeline Areas of Delta State, Nigeria

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Abstract
The rate of oil pipeline repairs and refined oil transportation through Delta State, Nigeria and its attendant environmental problems call for the need of regular monitoring of pollution prone areas particularly oil pipeline locations. In this study, water samples were collected from borehole and dug wells in some selected areas in Delta State where oil pipeline passes (experimental) and selected areas where oil pipelines are not situated (control). Samples were analyzed for physicochemical properties using standard methods. The physicochemical properties analyzed were pH, electrical conductivity, total dissolve solid, temperature, alkalinity oil and grease, total hardness, lead and manganese. The electrical conductivity and alkalinity of the study area were within recommended range of WHO, NAFDAC and SON. Total dissolve solid were within the recommended rage of the regulatory agency, except site 3B (111.5mg/L). The temperature of the water samples were above the stipulated value of 25°c as recommended by WHO, NAFDAC and SON. Total hardness of water were within recommended range of the monitoring agencies except sites 2B and 3B which had 364.00mg/L and 479.00mg/L respectively. Results of lead in the study area are within the recommended range of 0.01mg/L. There is no object able except site 1A and 1B. Results obtained from the study area indicate that ground water in the study area are contaminated. Amongst others, it is therefore recommended that ground water in the study area should be treated before usage.
Keywords: Ground water, Oil pipelines, and physicochemical properties

1.1 Introduction

Environmental pollution has become a part of our everyday life. The significance of our environmental factors to the health and well-being of human pollution is increasingly apparent (Rosenstock, 2003). Environmental pollution is a worldwide problem and its potential to influence the health of human population is great (Feradoum, Nurddin, Rxeza, Molisen, Ahme, & Pouria, 2007). Environmental pollution is tangled with the unsustainable anthropogenic activities, resulting in substantial public health problems (Khan, 2004). The water we drink are essential ingredients for our wellbeing and a healthy life. Unfortunately polluted water and air are common throughout the world (European Public Health Alliance, 2009). The WHO states that one sixth of the world's population, approximately 1.1 Billion people do not have access to safe water and 2.4 Billion lack basic sanitation (European Public Health Alliance, 2009).

Groundwater has been traditionally considered to be a pure form of water because of its filtration through soil and its long residence time on the ground (Emagbetere & Molua, 2012). However, groundwater is not as pure as traditionally assumed. This is because water is an excellent solvent and contains lots of dissolved chemicals.

Water contamination is a major global problem which requires ongoing evaluation and revision of water resources policy at all level (Ugbune, 2011). It has been suggested that water pollution is the leading worldwide cause of death and diseases (Pink, 2006).

A major consequence of human activities is the generation of waste; a necessity which should be planned for. This is because the environment- the place where you live becomes polluted as a result of these activities (Page Wise Inc., 2008) which include technology, industrialization, agriculture, education, oil exploration etc. In the study of the socio-economic impact of oil pollution (Worgu, 2000) stated that crude oil exploration has had adverse environmental effect on soil, forest and water in host communities in the Niger-Delta.

One of the sources of ground water contamination includes spills and leaks resulting from transport and storage of liquids. Leaks and spills can occur as hazardous liquids are transported via pipelines, trucks or trains or stored in tanks and other containers. If an underground storage tank develops a leak, which commonly occurs along the oil pipelines due to vanderlization or as the tank or pipe ages and corrodes, its contents can migrate through the soil and reach the groundwater. At the site of an accidental spill, the chemicals are often diluted with water and then washed into soil increasing the possibility of groundwater contamination (US EPA, 2002).

The activities of man in his daily endeavours cannot be complete in the absence of water. Water becomes an integral part of man and its important cannot be overemphasized. Over the years, people have suffered acute pains and death for drinking impure or contaminated water. In line with the above statement, Asokhia (1995) opined that "exploration for water, its exploitation and purification are therefore vital aspects of engineering geology.

Groundwater is the major source of drinking water for citizens of every nation. The day to day activities in our homes produce waste that can cause the groundwater to be contaminated. Even if nobody in your community uses groundwater for drinking, you need to be concerned. This is because groundwater that underlies your home may travel along the way and eventually end up as another family's drinking water. Against the background of the forgoing, ground water contamination has become a major problem in many communities. This made the researchers to embark on this study: assessment the level of groundwater contamination and its implications in oil pipeline areas of Delta State, Nigeria.

1.2 Purpose of the Study

The main purpose of this study is to assess the level of groundwater contamination and its implications in oil pipeline areas of Delta State, Nigeria. To achieve this main purpose, the following specific objectives are outlined:

1. To find out if the groundwater is contaminated in oil pipeline areas of Delta State, Nigeria
2. To find out the level of groundwater contamination and its implications in oil pipeline areas of Delta State, Nigeria
3. To find out if groundwater contamination is caused by oil explorations in Delta State, Nigeria

1.3 Implications of Contaminated Groundwater

The full impacts of groundwater pollution on health, agriculture and the environment have not been assessed comprehensively. In the case of health impacts, Pedley and Howard (1997:180) observe that:

> The contribution made by contaminated groundwater to the global incidence of waterborne disease cannot be assessed easily; for many countries the incidence of waterborne disease is not known accurately and the data for groundwater usage are not available. Where public health statistics are available, the data are insufficient to determine the source of the water involved in the transmission of the disease.

In the United States of America, substantial debate has emerged over the cost of cleanup in relation to the value of groundwater resources (National Research Council, 1997). In developing countries, demands on limited financial resources are often more intensive. As a result, more questions arise regarding large investments in pollution control that have few immediately observable returns.

The above observations do not imply that the human and environmental burdens associated with groundwater pollution are minor. Diseases related to water pollution are a major concern in many parts of the world. In 1994, cholera caused more than 10 000 deaths; in recent years, 25 000 deaths have been caused by typhoid, 110 000 by amoebae; and diarrhoeal diseases have claimed the lives of 3.2 million children under 5 years old (Pedley and Howard, 1997).

Safiuddin & Karim (2013), deposed that the implications of contaminated groundwater are categorized into two; social effects and effects on human health.

1.3.1 Social Effects

Contamination of groundwater has effects on people's lives. The sudden increase in arsenic related diseases has panicked the local people. The native people consider the arsenic diseases contagious. In many instances, the people suffering from arsenic diseases have been ostracized by neighbors, friends and relatives. The affected people are either avoided or discouraged to appear in public places. The affected children are often barred from attending schools and the adults are discouraged from attending offices and any public meetings. Qualified persons are refused jobs when found suffering from arsenicosis. Those affected with a higher level of contamination are considered incapable of working and hence victimized by the growing poverty.

1.3.2 Effects on Human Health

The data collected by the governmental bodies, NGOs and private organizations reveal that a large number of populations in Bangladesh are suffering from melanosis, leuco-melanosis, keratosis, hyperkeratosis, dorsum, non-petting oedema, gangrene and skin cancer. Melanosis (93.5%) and keratosis (68.3%) are the most common presentations among the affected people. Patients of Leucomelanosis (39.1%) and hyper-keratosis (37.6%) have been found in many cases. Few cases of skin cancer (0.8%) have also been identified among the patients seriously affected by the arsenicals (arsenite and arsenate).

1.3.3 Importance of Water

The specific role of groundwater in socio-economic development has been widely recognized for the past 50 years (United Nations, 2000). Groundwater continues to serve as a reliable source of water for a variety of purposes, including industrial and domestic uses and irrigation. The use of generally high-quality groundwater for irrigation (which is largely indifferent to water quality) dwarfs all other uses.

Water is important to the mechanics of the human body. The body cannot work without it, just as a car cannot run without gas and oil. In fact, all the cell and organ functions made up in our entire anatomy and physiology depend on water for their functioning. Water serves as a lubricant Water forms the base for saliva Water forms the fluids that surround the joints. Water regulates the body temperature, as the cooling and heating is distributed through perspiration. Water helps to alleviate constipation by moving food through the intestinal tract and thereby eliminating waste- the best detox agent.

Regulates metabolism In addition to the daily maintenance of our bodies, water also plays a key role in the prevention of disease. Drinking eight glasses of water daily can decrease the risk of colon cancer by 45%, bladder cancer by 50% and it can potentially even reduce the risk of breast cancer. And those are just a few examples! As you follow other links on our website, you can read more in depth about how water can aid in the prevention and cure of many types of diseases, ailments and disorders that affect the many systems of our bodies.

Since water is such an important component to our physiology, it would make sense that the quality of the water should be just as important as the quantity. Drinking water should always be clean and free of contaminants to ensure proper health and wellness (Frau, 2013).

1.3.4 Sources of Ground Water Contamination

Groundwater contamination may result from many sources, including current and past oil and gas production and related practices, agricultural activities, industrial and manufacturing processes, commercial and business endeavors, domestic activities, and natural sources that may be influenced by, or may result from, human activities. According to Stewart (2013) the following are sources of ground water contamination:

- Land Disposal of Municipal and Industrial Waste
- Sewage Treatment and Disposal
- Land Application of Liquid Wastes
- Spills and Leaks from Storage and Transport of Liquids
- Well Injection of Liquid Wastes
- Agricultural Activities
- Mining Activities
- Radioactive Waste
- Naturally Occurring Poor-Quality Water
- Surface Water and Atmospheric Contaminants
- Homes not connected to municipal sewage system usually use septic systems to dispose of waste water from toilets and drains

3.0 Methodology and Materials

3.1 Research Design

The Solomon 4 design was adopted for the study which is purely an experimental design.

3.2 Water Sample Collection

Water samples were collected from different boreholes and dug wells in some selected towns, where oil pipeline passes and some selected towns where oil pipelines are not situated in Delta State. They are Mosogar area, site 1A (borehole water sample) and 1B (dug well water sample); Adeje area, site 2A (borehole water sample) and 2B (dug well water sample); Ekpan area, site 3A (borehole water sample) and 3B (dug well water sample). Agbor area sample A (borehole water sample) and B dug well water served as control. The water sample from areas where oil pipeline passes serve as the experimental group, while the water samples from other areas served as the control group. In each of the sampling site, water samples were collected in plastic bottles, cleaned with 2m HNO_3 and rinsed with deionized water.

3.3 pH

A Philip analog pH meter was used to monitor the pH of all the water samples. pH was determine at the site of collection of water samples.

3.4 Conductivity

This was determined at the site of collection of water samples, using Wissen Schaftirchtechische conductivity meter.

3.5 Temperature

This was determined at the site of collection of water samples using mercury in glass thermometer.

3.6 Total Suspended Solids

Total Suspended Solids was determined by the filtration method. Water sample was filtered by the use of the filter paper. The filter paper residue will be dried in an oven for 30-40 minutes. At a temperature of about 105 °c, the difference in weight of filter paper before and after drying gives the total suspended solid (franson, 1975).

3.7 Total Dissolved Solids

This was done by using the evaporation method. Evaporating dish was used and 100cm^3 of the water sample was introduce into the weighed dish and was dried in an oven operating at 103°c for proper drying for 1hr. after drying it was transferred to a desicator and was left to cool for 1hr. The dish was finally weighed with its content. The difference in weight gives the weight of the total dissolved solids of the sample (Franson, 1975, IITA, 1970).

3.8 Alkalinity

50cm^3 of the water sample was pipetted into a 250cm^3 Erlenmeyer flask and three drops of phenolphthalein indicator was added and swirl. The solution was fitrated with standard H_2So_4 solution to a colourless end point. The titre was recorded as the alkalinity of the water sample (Franson, 1975; Vogel, 1989).

$$\text{Alkalinity (mg1}^{-1}\text{)} = \frac{\text{titre value X molarity X 1000}}{\text{Volume of Samples (cm}^3\text{)}}$$

3.9 Hardness Determination

50 cm^{3}of the water sample was introduced into a beaker and 1cm^3 buffer solution of NH_3 will be added. Three drops of solochrom Black T indicator was also added and it was stirred properly. The mixture was titrated with 0.01M Ethylenediamine acetic acid (EDTA) solution until colour changed from wine red to pure blue with no bluish tinge remaining. The total hardness of the water was calculated.

$$\text{Total hardness} = \frac{\text{Volume of titrant X 100}}{\text{Volume of Sample (cm}^3\text{)}}$$

3.10 Calcium Hardness

For the determination of calcium hardness 100cm^3 of the water sample was introduced into a beaker and 1cm^3 NaOH buffer was added. Three drops of mirazine indicator was also added to the solution and stirred. The mixture was again titrated with 0.01M EDTA solution until colour changes from red to deep red was noticed as the end point. The calcium hardness of the water was calculated as:

$$\text{Calcium hardness} = \frac{\text{Volume of titrant X 100}}{\text{Volume of Sample (cm}^3\text{)}}$$

3.11 Magnesium Hardness

The difference between total hardness and the calcium hardness of water was regarded as magnesium hardness (Vogel, 1989). While the carbonate was determined by the titrimetric method (Franson, 1975; IITA, 1970).

3.12 Chloride Content

100cm^3 of the water sample was measured into Erlenmeyer flask. The PH of the water was adjusted to 8 – 0 using Sodium Hydroxide solution 10cm^3 of Potassium Chromate was added to the solution. The mixture was then titrated with 0.014M $AgNo_3$ solution until the colour changed from colourless to Pinkish Yellow at the end point. A blank of 0.02cm^3 was used for the titration (Franson, 1975).

Titre value = Value of titrate – titre value of blank

$$\text{Chloride content (mg/L)} = \frac{\text{titrate x molarity of AgNo}_3\text{ x 35460}}{\text{Vol. of Sample}}$$

3.13 Metallic Ion and Heavy Metal Concentration

Metallic ion and heavy metal concentration were determined using AAS (Unicam 911).

3.14 Quality Control and Assurance

Analytical grade reagents were used for all the analysis. Water sample was collected with plastic made implements to avoid contamination. All the sampling containers that were utilized was pre-washed with detergent and rinsed with tap water followed by distilled water. The result matched with the regulatory Agencies: National Agency for Food, Drug and Control (NAFDAC); World Health Organization (WHO) and Standard

Organization of Nigeria (SON) standard.

4.0 Results and Discussions

The results of physiochemical parameter of ground water (borehole and dug wells) along oil pipeline in Delta State are presented in Table 1. Results of control sites are also in Table 1. For drinking water to be safe, the concentration of undesirable should not exceed the levels recommended by regulated agencies [NAFDAC; SON, and WHO].

Table 4.1: Results of Physicochemical Parameter of Ground Water along Oil Pipeline

S/N	Parameter	1A	1B	2A	2B	3A	3B	Control A	Control B	WHO	NAFDAC	SON
1	pH	5.29	5.10	4.98	6.44	5.82	6.44	6.45	6.46	6.5-8.5	6.5-8.5	6.5-8.5
2	Electrical conductivity (Ms/cm)	17.57	127.6	14.62	106.6	35.3	202	100.00	110	50.00	1000	1000
3	TDS (mg/L)	9.7	70.5	8.05	58.8	19.5	111.5	48.70	50.2	50.00	500	500
4	Temperature (°c)	30.0	30.1	30.6	30.7	30.2	30.1	26.00	26.00	25	25	25
5	Alkalinity (mg/L)	BDL	7.00	BDL	45.50	8.00	72.00	13.0	15.00	50.00	100	_
6	Oil & Grease (mg/L)	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	_	_	_
7	Total Hardness (mg/L)	_	6.00	_	364.00	17.00	479.00	6.5	6.8	500	100	500
8	Lead (mg/L	<0.002	0.753	<0.002	0.587	0.255	0.421	<0.002	<0.002	0.01	_	0.01
9	Maganese (mg/L)	<0.002	<0.002	<0.002	0.064	<0.002	0.079	<0.002	<0.002	0.05	2.00	2.00

Site 1: 1A (Borehole water sample), 1B (Dug well sample)
Site 2: 2A (Borehole water sample), 2B (Dug well sample)
Site 3: 3A (Borehole water sample), 3B (Dug well sample)

4.1 pH

The pH of the borehole water ranged from 4.98 – 5.82 while that of the dug wells ranged from 5.10 – 6.44. These values are lower than the control sample (Table 1) and are also below the recommended range of NAFDAC, SON and WHO. The result indicates that ground water of the study area is moderately acidic. The pH values of the ground water are significant enough to cause corrosion of pipes. A similar pH trend was also observed by Egereonu (2005).

4.2 Conductivity

The electrical conductivity in the study area ranged from 17.57 -35.3 Ms/cm, 106 – 202 Ms/cm for borehole and dug wells respectively. These values are within the range of control samples and also within the values recommended by regulatory agency (NAFDAC, SON, WHO).

4.3 Total Dissolve Solids

Total dissolve solid water include solid material that has been dissolved in water. The total dissolve solid falls within 9.7-35.3mg/L, 58.8 – 111.5mg/L for borehole water and dug well water respectively. The total dissolve solid of site 3B is above the recommended values of 500mg/L. The abnormal values of total dissolve solid in this site will give the objectionable taste.

4.4 Temperature

Result of temperature of the study area are in the range of 30.0°c – 30.6°c and 30.1-30.7°c, for borehole and dug well water respectively. These values are above the value of control sample and that of the recommended values of WHO. The high temperature range may be attributed to dissolve impurities.

4.5 Oil and Grease

The oil and grease of the sampling area are below the detection limit. Although, there is the presence of odour in sample 1A and 2B.

4.6 Alkalinity

The alkalinity of water is its ability to neutralize acid. The main ion responsible for alkalinity is hydrogen carbonate and hydrogen bicarbonate. The alkalinity ranged from BDL – 8.00mg/L, 7.00-72.00mg/L respectively for borehole water and dug well water respectively. The Alkalinity of the study area falls below the recommended values of 100mg/L.

4.7 Total Hardness

Magnesium and hydrogen carbonate ion are responsible for hardness in water. Total hardness of groundwater ranged from 0.00-17.00mg/L, 6.00-479.00mg/L for borehole and dug well water respectively. Total hardness for sites 2B and 3B are above the recommended guidelines of 100mg/L. there will be formation of lime scale kettle and wastage of soap of water in sites 2B and 3B if used for laundry operation.

4.8 Lead

There were no trace of lead in site 1A and 2B. The only trace of lead in borehole water is site 3A (0.255mg/L). The values of lead in dug well ranged from 0.421-0.753mg/L. The value of lead in site 3A is above the recommended standard of 0.01mg/L. These values can cause delay in physical and mental development along with attention span and learning abilities of children, for adult it can cause kidney problem and high blood pressure.

5.1 Conclusion

Result obtained from the study area indicates that the water is contaminated in terms of physicochemical parameter when compared with the standard set by WHO, NAFDAC and SON. The contamination is as a result of oil pipeline when compared, with control sample. This contamination can lead to water borne disease, corrosion of pipe and wastage of soap during laundry operation

6.1 Recommendations

The oil is a major source of energy and income in the country. As a result, the transportation of oil through pipeline, to enable every part of the country (Nigeria) to have it is very essential. Therefore, the following recommendations are made:

1. The government especially the office of the town planning should enforce a law discouraging the building of residential homes close to the oil pipeline.
2. The ground water in the study area should be treated before usage, to avoid the possible health hazards contaminated water can cause.
3. There should be an orientation for people living in oil pipeline areas on the implications of contaminated ground water and the possible sources of ground water contamination; which should be organized by the government under the auspices of the ministry of health.

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