Post Impact Studies of Hydrocarbon Leakage into Groundwater Wells of Egita/Obite Community, Rivers State Nigeria

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Abstract
Pipelines conveying flammable or explosive material, such as natural gas or oil, pose special safety concerns and there have been various accidents. Oil pipelines are made from steel or plastic tubes which are usually buried. The study investigated the groundwater condition of two oil producing communities (Obite and Egita) after a snubbing operation to stop the eruption of gases both in the facility and the surrounding villages, as a result of pipeline accident in April, 2012. The operation involved installation of concentric pipes in the well to pump in heavy fluid and stop the flow of reservoir fluids. Samples of groundwater were collected from selected five sample stations during the month of October, 2014 in the study area using sterilized plastic and metal buckets, and transported to the laboratory for analysis. Standard analytical methods were adopted both for field sampling and laboratory analysis. The results of the analysed samples indicated that the groundwater was slightly acidic as a result of organic pollution by leakage of the hydrocarbon into the wells. The measured concentration of faecal coliform exceeded WHO safe limit for drinking water. However other parameters analysed were within the standard limits of WHO. The results revealed that the snubbing operation over the gas accident minimized adverse impact on the groundwater as most of the physicochemical variables were within safe limits. There was a possibility, the impact had been attenuated by nature.
Keywords: Groundwater, Pipeline Accident, Impacts, Hydrocarbon.

INTRODUCTION:

Nigeria has a population of over 110 million people (NPC, 2009) and an abundance of natural resources, especially hydrocarbons. It is the most populous African nation(Fig 1),10th largest oil producer in the world, the third largest in Africa and the most prolific oil producer in Sub-Saharan Africa(BP,2011).However, it’s global oil producing ranking has gone downward recently (IEA,2012) . The Nigerian economy is largely dependent on its oil sector which supplies 95% of its foreign exchange earnings. The Niger Delta region is home to most of the Nigerian oil wells, but the area has failed so far to enjoy the benefits of such huge revenues (kehinde *et al* 2014). The unequal distribution of oil wealth, along with agitation for self determination and resource control, has led to the sabotage of oil installations.

Fig.1 Map of West Africa showing Nigeria **Source**: Goggle, 2014

The upstream oil industry is Nigeria’s lifeblood and yet the oil industry poses a potential hazard for the environment and may impact it at different spheres (Emilio *et al*., 2004). Obite and Egita are major oil producing communities in the Niger delta area of Nigeria, characterised by shallow ground water wells which incidentally are the predominant sources of drinking water. Oil exploration and drilling are the predominant industrial activities in the area for over forty years (Eluozo, 2006). Most of this is produced from the prolific Niger River Delta. Despite problems associated with ethnic unrest, border disputes and government funding, Nigeria's wealth of oil makes it most attractive to the major oil-multinationals, most of who are represented in Nigeria, with the major foreign stakeholder being Shell. Nigeria produced an average of 2401.6 thousand barrels of crude oil per day in 2010, 2.94% of the world and a change of 16.2 % compared to 2009(MBendi, 2014)

According to the 2011 BP Statistical Energy Survey, Nigeria had 2010 proved natural gas reserves of 5.29 trillion cubic metres, 2.82% of the world. Due, mainly, to the lack of a gas infrastructure, 75% of associated gas is flared and 12% re-injected. Nigeria had set a target of zero flare by 2010 provided incentives for the production and use of gas. The government also planned to raise earnings from natural gas exports to 50 percent of oil revenues by 2010. It has been reported in the 2011 BP Statistical Energy Survey that Nigeria had 2010 natural gas production of 33.63 billion cubic metres, a change of 35.6% versus 2009 and equivalent to 1.05% of the world total. Nigeria's downstream oil industry is also a key sector including four refineries with a nameplate capacity of 438,750 bbl/d. Problems such as fire, sabotage, poor management, lack of turnaround maintenance and corruption have meant that the refineries often operate at 40% of full capacity, if at all. This has resulted in shortages of refined product and the need to increase imports to meet domestic demand. Nigeria has a robust petrochemicals industry based on its substantial refining capacity and natural gas resources. The petrochemical industry is focussed around the three centres of Kaduna, Warri and Eleme.

The upstream oil industry is the single most important sector in the country's economy, providing over 90% of its total exports. The social and environmental cost of oil production has been extensive. They include destruction of wildlife and biodiversity, loss of fertile soil, pollution of air and drinking water, degradation of farmland and damage to aquatic ecosystem; all of which have caused serious health problems for the inhabitants of the area surrounding oil production (Effiong, 2004). Oil is produced from five of Nigeria's seven sedimentary basins: the Niger Delta, Anambra, Benue Trough, Chad, and Benin. The Niger Delta, the Onshore and Shallow Offshore basins can be considered fairly well to well explored. Ventures here are low risk and the basins contain about 80% of producing wells drilled in Nigeria. During the later 1990s exploration focus turned to high risk ventures in the frontier basins of the deep water offshore with encouraging success. These ventures are becoming increasingly attractive with developments in deepwater exploration and production technology.

Nigeria is a member of OPEC. Its crude oils have a gravity between 21·API and 45·API. Its main export crudes are Bonny Light (37·) and Forcados (31·). About 65% of Nigeria's oil is above 35·API with a very low sulphur content. Nigeria's OPEC quota is 1.89 million bbl/d(MBendi,2014)..

The downstream oil industry in Nigeria is another key sector in the country's economy. The country has four oil refineries and there are eight oil companies and 750 independents all active in the marketing petroleum products. Cross-border smuggling is an ongoing problem and there are frequent reports of large scale corruption in the distribution and marketing chain. The government through its 100% state-owned national oil company, Nigerian National Petroleum Corporation (NNPC) has had an all encompassing control over the industry through its shareholding in all the companies involved and in the setting of wholesale and retail prices.

Some facilities linked to Oil and Gas in Nigeria

- Amukpe Field - Nigeria
- Block 315
- Nigeria OPL 281
- Oben Field - Nigeria
- Okporhuru Field - Nigeria
- OML - 122 - Nigeria
- OML - 125 - Nigeria
- OML - 13 (Qua Iboe Field) - Nigeria
- OML - 131 - Nigeria
- OML - 134 - Nigeria
- OML - 145 - Nigeria
- OML - 38 - Nigeria
- OML - 4 - Nigeria
- OML - 41- Nigeria
- OML - 56 (Ebendo Field) - Nigeria
- OML 29 - Nigeria
- OPL - 283 - Nigeria
- OPL 2008 - NIgeria
- OPL 321 - Nigeria
- OPL 323 – Nigeria (**SOURCE**: MBendi Information Services 2014)

Some Projects linked to Oil and Gas in Nigeria

- Aboh
- Akpo field development
- Dangote Oil Refinery - Lekki
- Egina Oil Field
- Ogedeh Project
- Ogini and Isoko fields
- Okwok
- OML 123
- OML 124
- OML 126
- OML 137
- OML 30
- OML 38 Marginal Field
- OPL 227
- OPL 233
- OPL 241
- OPL 281
- OPL 283
- OPL 291
- OPL 310

(**SOURCE**: MBendi Information Services 2014)

Industry Sector Profiles for Oil and Gas in Nigeria

- Extraction of Crude Petroleum
- Extraction of Natural Gas
- Natural Gas Liquid Extraction
- OiI and Gas Industry Regulation
- Oil & Gas Exploration
- Oil and Gas (General)
- Oil Refining
- Petroleum and Petroleum Products Wholesalers
- Petroleum Lubricating Oil and Grease Manufacturing
- Support Activities for Oil and Gas Operations

(**SOURCE**: MBendi Information Services, 2014)

In many parts of Nigeria, ground water sources from underground wells constitute the major supply of domestic needs. This water may become contaminated due to subsurface leakage from oil exploration, leachates from dumpsites, animal and plant wastes, fertilisers, chemicals among others. Many Nigerians are drinking water with high and dangerous levels of hydrocarbons due to the problem of petroleum sipping into groundwater. Baruwa community is an example of a place where residents drink water with high petroleum content. Niger delta communities are affected too (Ogbuagu, 2011).

Oil spillage has been the greatest source of groundwater petroleum hydrocarbon pollution in Nigeria. Common causes of this phenomenon include damages to storage vessels, ruptures of oil pipelines, oil tank overflow, weakness of laws and their feeble enforcement, sabotage by aggrieved people and/or communities. A total of 6,817 oil spills were reported in Nigeria between 1976 and 2001 (UNDP, 2006).

The, Head of Baruwa village and the analyst drawing water from one of the wells for sampling, December 31, 2012

Ageing pipelines and tanks used by the Nigerian National Petroleum Corporation (NNPC), investigations have revealed are the major cause of the massive pollution, resulting in ailments and shorter life spans for the millions of the citizens. In the Niger Delta where oil prospecting and production takes place, it was found that the people drink a poisonous cocktail of water and crude oil**.** Investigations confirmed that many people in areas where oil pipelines and tank cross both within and outside the Niger Delta where oil production takes place are ingesting high and dangerous levels of hydrocarbons (Tubonimi *et al.,* 2010).In parts of Warri, Delta State, Ogoni in Rivers State, the water is heavily polluted. The United Nations Environment Programme (UNEP) carried out studies that confirmed the contamination of groundwater in Ogoni area as well as the soil. The UNEP recommended the need to clean up the region and the federal government had noted that the clean-up of contaminated soil will take decades. Even in Kaduna leaking pipelines have contaminated the groundwater. Contamination of groundwate**r** is of great consequences since it is the only source of safe drinking water for the local communities and it is often times used untreated. Drinking contaminated groundwater can have serious health effects. Health effects from groundwater pollution depend on the specific pollutants in the water. Ingesting polluted water often causes diarrhoea and stomach irritation and more severe effects (Nguendo-Tongsi, 2011)**.** From the results, the petroleum products contain carcinogenic substances like Benzene, Toluene etc. and exposure to low doses over time can cause cancer in that area. Drinking water contaminated with oil can cause a lot of vomiting. Studies have also shown that oil can affect the skin. There are many diseases that can occur when people are exposed to such water on a long-term. According to World Health Organization (WHO) standard good water must be colourless, odorless.

From extraction to end use, petroleum products affect surface water and ground water, impairing water quality with hydrocarbons, salts, nutrients, a host of organic compounds, and various heavy metals. In many areas around the world, oil spills and storm water runoff containing oil derivatives have degraded ecosystems and human water supply. Petroleum, also known as crude oil, comes from the remains of prehistoric life subjected to heat and pressure for millions of years. Over time, petroleum accumulated in oil fields, between layers of impermeable rock. Crude oil is extracted from these fields through a series of recovery methods that run from tapping into the fields' initial pressure (known as primary recovery) to pressurizing the fields with water or steam or other gases to force the oil to the surface (known as secondary and tertiary, or enhanced, recovery).

Natural Gas

Natural gas is a subcategory of petroleum that is a naturally occurring complex mixture of hydrocarbon with a minor amount of non-hydrocarbon gases. The discovery and extraction of natural resources have brought different consequences to countries that are endowed with such resources. Like petroleum, natural gas comes from organic matter subjected to intense heat and pressure for millions of years. Natural gas can be produced from dedicated wells or coproduced with oil from oil wells. Most commonly, wells permit natural gas to flow to the surface naturally; however, in some geologic conditions, lifting equipment, such as rod-pumping, is required (Allen *et al*,2014).

Natural gas production degrades water quality primarily at the extraction stage, though processing and combustion also affect water quality to lesser degrees.

Natural gas extraction can generate large volumes of produced water, often contaminated by hydrocarbon residues, heavy metals, hydrogen sulfide, and boron, as well as elevated concentrations of salts. Clark and Veil, (2009) report that gas extraction generates about one-sixth as much produced water as petroleum extraction, at an average rate of 182 barrels of water per million cubic feet of production.

Methane is the main compound of natural gas as used by consumers, but natural gas deposits contain a mixture of other compounds that must be removed before the methane is suitable for use by the consumer. Once extracted, gas undergoes initial processing near the wellhead. The gas is then transported, typically via pipeline, to a processing plant for further purification, to separate methane from other compounds in the raw natural gas, including propane, butane, water vapor, hydrogen sulfide, and carbondioxide. Some of these, such as propane and butane, have commercial value. Water, hydrogen sulfide, and other compounds must be removed and treated or retained by the processing plant, to avoid environmental contamination. The purified natural gas is then delivered to end users, again typically via pipeline, though in remote areas it is often cooled and transported via tankers as liquid natural gas.

Burning natural gas leaves negligible solid waste and generates far fewer particulates than burning coal or petroleum. Like all fossil fuels, natural gas combustion generates carbon dioxide and nitrogen oxides, though at markedly lower rates than coal combustion.

Methane itself is also a greenhouse gas, contributing to the heat-trapping capacity of the atmosphere, and like carbon dioxide, its concentration has risen dramatically in the past century.

Pipeline accidents in Nigeria

Pipelines conveying flammable or explosive material, such as natural gas or oil, pose special safety concerns. Pipeline transport is the transportation of goods through a pipe. Liquids and gases are transported in pipelines and any chemically stable substance can be sent through a pipeline. Pipelines exist for the transport of crude and refined petroleum, fuels - such as oil, natural gas and biofuels - and other fluids including sewage, slurry, water, and beer. Pipelines are useful for transporting water for drinking or irrigation over long distances when it needs to move over hills, or where canals or channels are poor choices due to considerations of evaporation, pollution, or environmental impact. Pneumatic tubes using compressed air can be used to transport solid capsules. Oil pipelines are made from steel or plastic tubes which are usually buried. The oil is moved through the pipelines by pump stations along the pipeline. Natural gas (and similar gaseous fuels) are lightly pressurised into liquids knows as Natural Gas Liquids (NGLs). Natural gas pipelines are constructed of carbon steel. Highly toxic ammonia is theoretically the most dangerous substance to be transported through long-distance pipelines, but accidents have been rare. Hydrogen pipeline transport is the transportation of hydrogen through a pipe. District heating or *teleheating* systems use a network of insulated pipes which transport heated water, pressurized hot water or sometimes steam to the customer. Pipelines conveying flammable or explosive material, such as natural gas or oil, pose special safety concerns and there have been various accidents. Pipelines can be the target of vandalism, sabotage, or even terrorist attacks. In war, pipelines are often the target of military attacks .Hereunder are some cases of accidents involving pipeline explosion:

- 1998: At Jesse in the Niger Delta in Nigeria, a petroleum pipeline exploded killing about 1200 villagers, some of whom were scavenging gasoline. The worst of several similar incidents in this country. (October 17, 1998)
- 2000: Another pipeline explosion near the town of Jesse killed about 250 villagers.(July 10, 2000)
- 2000: At least 100 villagers died when a ruptured pipeline exploded in Warri. (July 16, 2000)
- 2000: A leaking pipeline caught fire near the fishing village of Ebute near Lagos, killing at least 60 people. (November 30, 2000)
- 2003: A pipeline punctured by thieves exploded and killed 125 villagers near Umuahia, Abia State. (June 19, 2003)
- 2004: A pipeline punctured by thieves exploded and killed dozens of people in Lagos State. (September 17, 2004)

- 2006: An oil pipeline punctured by thieves exploded and killed 150 people at the Atlas Creek Island in Lagos State. (May 12, 2006)
- 2006: A vandalised oil pipeline exploded in Lagos. Up to 500 people may have been killed. (December 26, 2006)
- 2008: The 2008 Ijegun pipeline explosion (May 16)

Source:Petroleum Industry,2008.

Gas eruption from an oil facility into the groundwater of the study area

An incident occurred on the 3rd of April,2012, in an operating facility of Total Exploration and Production Nigeria Limited(TEPNG)-*Ibewa Cluster* which is under OML(Oil and Lease) 58 which could possibly contaminate the ground water in the area and render it unsafe for domestic use. Total Exploration and Production Nigeria (TEPNG) was alerted by some villagers about some water and gas resurgence points, observed in an uninhabited area close to its onshore Obite gas production facilities, on an OML 58 license.OML 58 is a concession operated by TEPNG on behalf of the Nigeria National Petroleum Company(NNPC)/Total Joint Venture in Ogba/Egbema/Ndoni Local Government Area, Rivers State Nigeria. According to a report by TEPNG, this incident occurred as a result of the drillers puncturing an existing gas flow in the process of drilling for another gas well. This resulted in the eruption of gases both in the facility and adjourning community.

The snubbing intervention started on May, 9th 2012. Six weeks after the gas resurgence was noticed and it ended on 18th may, 2012. (Cement seals were in place and permanent abandonment of the well progressed as planned). A snubbing operation consists of introducing small pipes into the well to pump heavy fluid to stop the flow and set cement plugs to isolate the reservoir. Two relief wells were also drilled to aid the snubbing operation.

Fig.2 Gas eruption from pipeline at the study area

Fig.3 Gas eruption from a pipeline at the study area

Fig:4 TEPNG workers and some members of community during snubbing operation

Fig.5 Cement seals put in place during snubbing operation

LOCATION OF STUDY AREA

The study area consists of Obite and Egita community of Egi clan in Ogba/Egbema/Ndoni local government area of Rivers State; and lies between longitude (6°39'27.81"E) and latitude (5°15'3.06"N), and longitude (6°41'1.10"E) and latitude (5°14'58.17"N) respectively(Fig 5). For purposes of comparison the control station during sampling was at Obigwe community in Igburu clan where the impact was minimal.

The vegetation in the area is typically tropical rain forest with fringes and patches of fresh water swamps along the rivers and creeks and within depressions and valley bottom. There are several towns in the area and land use of the communities in the area consists mainly of farming and fishing.

Ogba/Egbema/Ndoni Local Government Area of Rivers State is part of the Niger Delta Environment that developed from the Moto Delta in the Northern part Basin during the companion transgression and ended with the Paleocene transgression. Ogba/Egbema/Ndoni of Rivers State is generated from the Niger Delta modern formation during the Eocene. It has three major depositions just like every other part of the Deltaic Environment. The three major formations are Benin, Agbada and Akata formation. It was estimated that one million cubic meter of sand are carried towards mahin every year, while the Niger-Benue system brings a sediment load of 0.2kilometrecubic/year which is deposited on top of the Delta(Irwin and Oghenevwede,2014).

Benin formation i.e. ground water is predominant in Ogba/Egbema/Ndoni Local

Government Area of Rivers State disintegrating to sombrero that transit at the Ahoada River at about 100ft or more. The geologic history of Ogba/Egbema/Ndoni is predominated by the deposited formation. According to Eluozo*, (2006)* the stratigraphy of Ogba/Ebema/Nodni Local Government Area of Rivers State are deposited by locustrine and Alluvial, including off lap sediments, the locustrine deposit in the area is heterogeneous predominant while alluvial deposits are homogenous predominant. The coastal areas are off lap by sediments including tidal channels at 60ft and 800ft respectively.

The deposit disintegrating from Benin formation, are known to be the highest yield formation i.e. unconfined aquifer, Ogba/Egbema/Ndoni Local Government Area of Rivers State, predominantly 90% of cobble coarse and gravel and 5% of sand stone and sedimentary deposit including montomollilorite clay. The minerals that are deposited in the area are hazardous chemical from man-made activities and natural origin, e.g. iron oxide in some communities like Obagi, Ogbogu Obite, Obiyebe, Ede and Obigwe. It has an average static water table of 7.5m water table. While in most coastal environment, it has an average of 1.5m water table *(*Eluozo*, 2006).*

The study by Eluozo*, (2006)* also confirms that a good aquiferous zone has an average depth of 36m in the upland area, while in the coastal area it is 12-15metres deep. Finally the Porosity of the soil was confirmed to be very high at an average of 0.2-0.4 percent*. (*Ukpaka*, 2010)*

The study area covers 3 communities within Egi Land and environs. Two (2) of these communities are close to the operational area of oil exploration and exploitation, whereas, the other community is far away from the operational area.

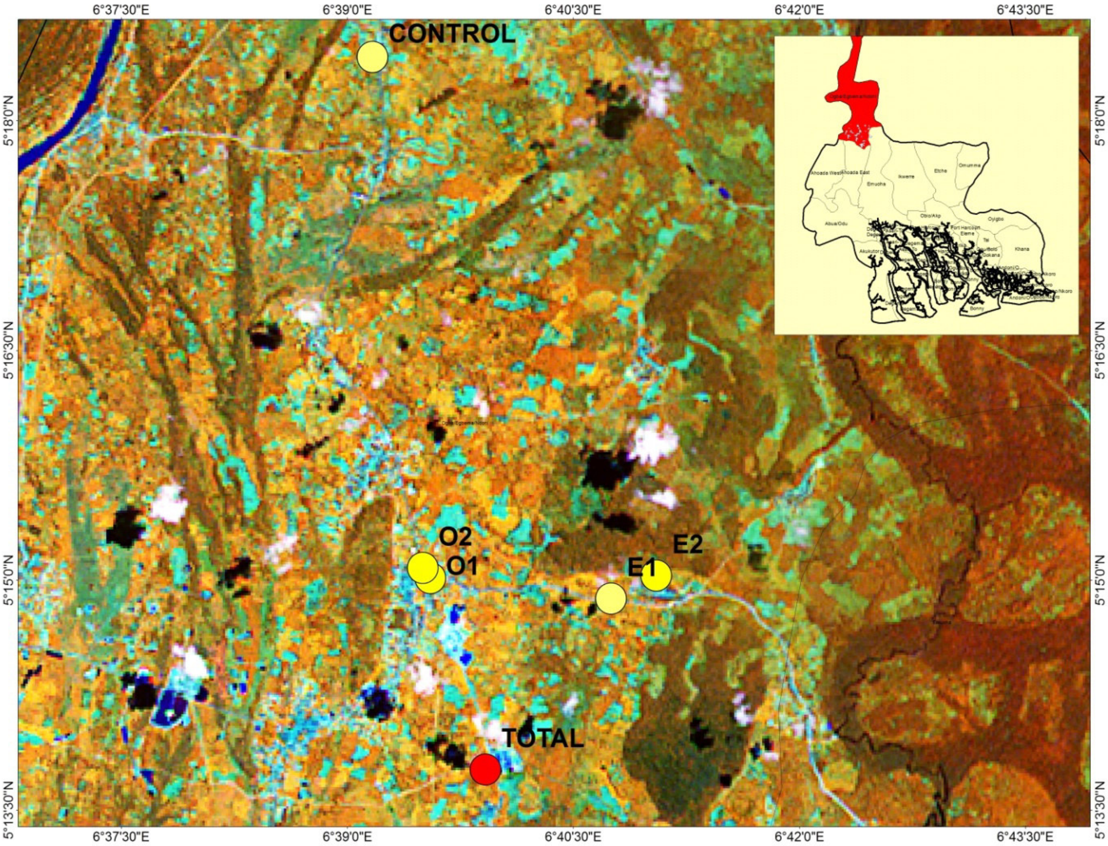

Figure6: location map of study area showing sampling stations

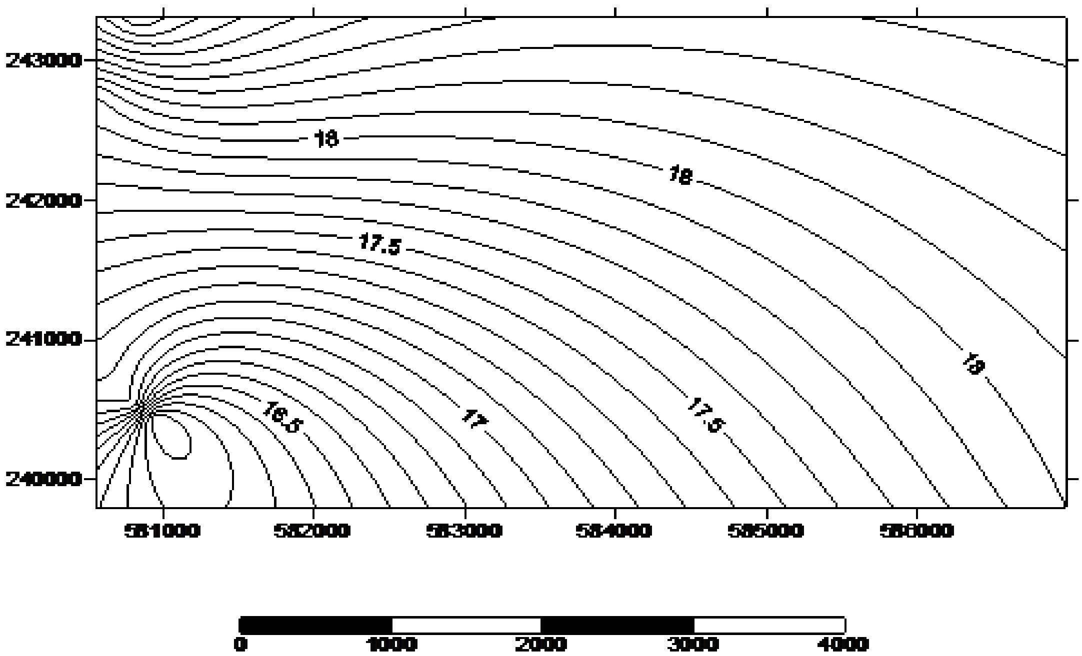

Figure 7: contour map of study area

Methodology

Prior to commencement of the sampling exercise, a reconnaissance survey was carried out to acquire information about the site condition and environment; identify sampling points, ascertain potential challenges that may arise during the sampling etc. The following where achieved during the reconnaissance survey;

- Five sampling points where identified within the communities and were named; E1 and E2 for Egita community, O1 and O2 for Obite community and C for control station i.e. Okposi community which is about 3km away from the resurgence point.
- Because of the volatile nature of the area, harmonious community relationship was established.
- A sampling plan was also developed.
- Transportation and movement of sample bottles, ice and preservatives posed a challenge but was resolved.
- Representative samples were collected from the five sample station using the appropriate equipment. The following parameters were measured in situ: pH, temperature, conductivity, turbidity and salinity because of their fast changing nature. Temperature, pH, turbidity and salinity were measured in situ using a multi-probe meter while electrical conductivity was measured using conductivity meter.

The pH was measured using a Phillip probe meter. Turbidity is a measure of the dispersion of light in a column of water due to suspended matter. The higher the turbidity the cloudier the water appears. If water becomes too turbid it loses the ability to support a wide variety of plants and aquatic organism. Turbidity is measured in Nephelometric Turbidity Units (NTU's).

Prior to measurement, the turbidity meter was calibrated using a distilled water and after the calibration, 10ml of the sample was introduced into the cuvette and placed in its holder in the meter and it was turned on. It was left for about 4minutes and the reading of the turbidity was noted.

For heavy metals, prior to the analysis all apparatus to be used were sterilized. The Sample Preparation procedure was as follows**:**

- 100ml of sample digested with nitric acid was poured into a measuring cylinder.
- 10ml of sample was filtered into a 10ml plastic bottle using a Whitman filter paper.
- The sample was transferred to Atomic Absorption Spectrometer (AAS) for analysis

  For the analysis of Total Hydrocarbon the multi Hach multi parameter was used. For determination of nitrate and phosphate, ASTMD 3867 and ASTMD 515 methods were used. The measurement procedure was as follows:

- The program number corresponding to phosphate LR was selected on the secondary LCD by pressing program.
- 10ml of unreacting sample was introduced into a cuvette and the cap was replaced.
- The cuvette was placed into the holder and the lid was closed
- The zero key was pressed.
- Waited for few seconds and the meter displayed "0.0". The meter is zeroed and ready for use.
- The cuvette was removed and one packet of phosphate reagent was added.
- The cap was immediately replaced and shaken vigorously for 2minutes by moving the cuvette up and down until powder is completely dissolved.
- The cuvette was reinserted into the meter.
- The TIMER was pressed and the display showed countdown. Waited for 3minutes and the read direct button was pressed.
- Waited for 5minutes. The concentration was displayed in mg/l.

For determination of magnesium ASTMD 511 method was used. Chloride was determined by multi-parameter meter using Philip method.

For bacteriological measurements, membrane filtration method was used to measure faecal coliform. Samples to be tested were passed through a membrane filter of particular pore size (generally 0.45 micron). The microorganisms present in the water remained on the filter surface. When the filter was placed in a sterile petri dish and saturated with an appropriate medium, growth of the desired organisms is encouraged, while that of other organisms is suppressed. Each cell developed into a separate colony, which can be counted directly, and the results calculated as microbial density.

1 ml and 10 ml of sample was used for the water testing, with the goal of achieving a final desirable colony density range of 20-60 colonies. Contaminated sources may require dilution to achieve a "countable" membrane.

A 100 ml volume of the water sample was drawn through a membrane filter (45 m pore size) through the use of a vacuum pump. The filter was placed on a petri dish containing M-FC agar and incubated for 24 hours at 44.50^{o} C. This elevated temperature heat shocks non-fecal bacteria and suppresses their growth. As the fecal coliform colonies grow they produce an acid (through fermenting lactose) that reacts with the aniline dye in the agar thus giving the colonies their blue colour

Results

The pH value of Egita sampling station ranged between 5.66 at E2 to 6.10 at E1.

The temperature values for Egita groundwater were 28.4˚C and 28.9 ˚C

The concentration of turbidity at Egita sampling stations ranged between 22.6NTU to 1.36 NTU at E1 and E2 respectively. The concentration of nickel, lead and cadmium in the sampling stations were less 0.001mg/l (0.001mg/l). The concentration of iron at E1 was <0.001 and 0.087mg/l at E2.The concentration of nitrate in Egita was 2.80mg/l in E1 and 2.40mg/l in E2 respectively. The concentration of phosphate in Egita was 0.32mg/l and 0.20mg/l in E1 and E2 respectively. The concentration of chloride at Egita inn the sampling stations were <0.001mg/l. The values of magnesium were 43.1mg/l and 36.5mg/l in E 1and E2.The concentrations of calcium were 72.4mg/l and 68.2mg/l in E1 and E2 respectively. The concentration of hydrocarbon was also less the 0.001mg/l in the sampling stations. The concentration of feacel coliform ranged between 65mpn/100 and 40mpn/100 in E1 and E2 respectively.

Table2: Measured parameters of Egita groundwater

S/N	PARAMETERS	SAMPLE IDENTITY/ RESULTS			WHO LIMIT (2004)
		E1	E2	C	
1	pH	6.10	5.66	4.91	6.5-7.5
2	Temperature(˚c)	28.4	28.9	28.9	27-30
3	Turbidity(NTU)	22.6	1.36	1.04	25
4	Lead(pb) mg/l	<0.001	<0.001	<0.001	0.01
5	Cadmium(cd) mg/l	<0.001	<0.001	<0.001	0.003
6	Iron(Fe) mg/l	0.087	<0.001	<0.001	0.3
7	Nickel(Ni) mg/l	<0.001	<0.001	<0.001	0.05
8	Nitrate mg/l	2.80	2.40	1.30	10
9	Phosphate mg/l	0.32	0.20	0.15	1.0
10	Calcium mg/l	72.4	68.2	68.5	75
11	Magnesium mg/l	43.1	36.5	41.4	50
12	Chloride mg/l	<0.001	<0.001	<0.001	250
13	THC(mg/l)	<0.001	<0.001	<0.001	
14	Faecal Coliform (mpn/100ml)	65	40	30	

4.2 RESULT OF MEASURED PARAMETER AT OBITE COMMUNITY

The pH value of Obite sampling station ranged between 5.15 at O2 to 5.41 at O1.The temperature values for Obite groundwater were 29.1˚C and 29.2 ˚C in O1 and O2 respectively.The concentration of turbidity at Obite sampling stations ranged between 0.93NTU to 1.16 NTU at O1 and O2 respectively.The concentration of nickel, lead, iron and cadmium in the sampling stations were <0.001mg/l.The concentration of nitrate in all the sampling stations ranged between 3.60mg/l and 2.70mg/l in O1 and O2 respectively.The concentration of phosphate in Obite was 0.28mg/l and 0.34mg/l in O1 and O2 respectively.The concentration of chloride at Obite in the sampling stations were <0.001mg/l.The values of magnesium were 38.6mg/l and 36.5mg/l in E 1and E2.The concentrations of calcium were 72.4mg/l and 40.4mg/l in O1 and O2 respectively.The concentration of hydrocarbon was also less the 0.001mg/l in the sampling stations. The concentration of feacel coliform ranged between 33mpn/100 and 34mpn/100 in O1 and O2 respectively.

Table3: Measured parameters of Obite groundwater.

S/N	PARAMETERS	SAMPLE IDENTITY/ RESULTS			WHO LIMIT (2004)
		O1	O2	C	
1	pH	5.41	5.15	4.91	6.5-7.5
2	Temperature(˚c)	29.1	29.2	28.9	27-30
3	Turbidity(NTU)	0.93	1.16	1.04	25
4	Lead(pb) mg/l	<0.001	<0.001	<0.001	0.01
5	Cadmium(cd) mg/l	<0.001	<0.001	<0.001	0.003
6	Iron(Fe) mg/l	<0.001	<0.001	<0.001	0.3
7	Nickel(Ni) mg/l	<0.001	<0.001	<0.001	0.05
8	Nitrate mg/l	3.60	2.70	1.30	10
9	Phosphate mg/l	0.28	0.34	0.15	1.0
10	Calcium mg/l	64.6	69.1	68.5	75
11	Magnesium mg/l	38.6	40.4	41.4	50
12	Chloride mg/l	<0.001	<0.001	<0.001	250
13	THC(mg/l)	<0.001	<0.001	<0.001	NS
14	Faecal Coliform (Mpn/100ml)	33	34	30	2

The pH recorded the lowest values of 5.15(Obite) and 5.66(Egita) at sections of the sampled groundwater which renders it slightly acidic. The low pH is indicative of organic pollution by hydrocarbon on the groundwater as a result of oil activities generally and the resurgence in particular. Ground water can become unusable if it becomes polluted and is no longer safe to drink .In areas where the material above the aquifer is permeable, pollutants can seep into ground water(Hirsch,2014).Ground water can be polluted by seepage through landfills, from septic tanks, from leaky underground fuel tanks, and sometimes from fertilisers or pesticides used on farms. This increased acidity could also be attributed to the presence of acidic metabolites introduced as a result of oil exploration activities, (Akubuenyi, 2013). However, with careful use and by reducing sources of pollution at the study area, groundwater can continue to be an important natural resource in the future. Turbidity values which ranged from 0.93 NTU (at Obite 1 station) to 22.4 NTU (at Egita 1 station) indicates that turbidity was within the recommended WHO (2004) safe limit. However, the value was highest at Egita 1 station and this could be attributed to the fact that the resurgence affected Egita community directly. The turbidity value of all the stations did not exceed WHO (2004) safe limit. The concentrations of faecal coliform obtained were far above the recommended maximum allowable limit by WHO (2004) 0f 0mpn/100ml. The value ranged from 30mpn/100ml (at control station) to 65mpnn/100ml (at Egita 1 station). This is indicative of high bacteriological contamination of the groundwater resulting from leachate of domestic and animal waste into the groundwater, thus rendering the water unsafe for drinking. Nguendo-tongsi *et al,* 2013 asserted that the entry of bacteria into water could be attributed to seepage from nearby septic tanks. Pollution of surface water can cause degradation of ground water quality and conversely pollution of ground water can degrade surface water. Thus, effective land and water management requires a clear understanding of the linkages between ground water and surface water as it applies to any given hydrologic setting (Hirsch, 2014).

The values obtained for Total Hydrocarbon Content THC, nitrate, phosphate, calcium, magnesium, chloride were all within the recommended allowable limit by World Health Organisation, WHO standard. The analysed heavy metals lead, cadmium, nickel and iron did not adversely affect the ground water as their concentrations were within the standard limits of WHO.

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