Effects of Siting Domestic Wastewater Facilities Near Boreholes on Groundwater Quality: A Case Study of Ughell North Delta State, Nigeria.

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Abstract- In Ughelli, pipe borne water supply is non-existent presently; hence many homes resorted to boreholes as a source of water for drinking and other household uses. Five borehole waters in selected areas at Ughelli were investigated for possible interaction of wastewater facilities effluents. The selected locations are Afiesere Road, Evueta Street, Egor Street, Ekiugbo Primary School and Iwhenene area designated BH1, BH2, BH3, BH4 and BH5 respectively. The elevations, coordinates of the locations and distances of boreholes from wastewater facilities were determined using the Global Positioning System (GPS) device and a tape rule respectively. The parameters analyzed and results were: appearance, pH 4.0 to 4.9; electrical conductivity (EC) 19.0 to 140.0 (µS/cm), temperature 26.0 to 31.0 and turbidity 1.0 to 1.8(NTU). Other determinants were total dissolved solids (TDS)12.8 to 96.2(mg/l);sulphates 2.87 to 15.44(mg/l); nitrates 2.1 to 18.93(mg/l); ammonium 0.08 to 8.72(mg/l); bio-chemical oxygen demand 0.5 to 0.7(mg/l); total coliform bacteria (TCB) 9.6 to 17.2(cfu), and e-coli BDL to 3.5(cfu).The parameters analyzed are those that were relevant to the assessment of water contamination by domestic effluents from wastewater facilities. Also, the levels of contaminants slightly increased with decreasing distance from wastewater facilities for total coliform bacteria (TCB) and e-coli with relation to elevation of the area. The results obtained in the various locations were compared with World Health Organization Standard for Drinking Water (WHO 2008 and NSDWQ 2007). The results indicated that the selected boreholes in Ughelli that were sited up-slope relative to wastewater facility and more than 5m away from the wastewater facility have values of most physico-chemical parameters that were within the World Health Organization (WHO) standards. The findings from this study showed that water quality was slightly affected by seasonal variation and the distance of the borehole from the wastewater facility. The contamination problems in borehole water from Ughelli needs stringent management measures to be put in place by the local and State Government to safeguard the human health and environment.

I. INTRODUCTION

Water is one of the most essential commodity of life apart from air.

With rapid population growth worldwide and an increased demand for essential amenities, the need for clean and adequate water for domestic use is one of the factors that need urgent attention (Mumma, *et.al;* 2011). A direct result of this is water scarcity and inaccessibility to potable water by people. It is therefore inevitable to address the issue of provision of potable and safe drinking water that is essential for life. To fulfill this demand, groundwater is increasingly used as a water source globally (Mumma*et.al*; 2011). “Groundwater makes up 97% of all the fresh water reserve in the world and is the most exploited natural resources” (Mumma *et.al;* 2011). Freshwater availability varies from place to place, country to country and continent to continent either as surface or groundwater.

This important natural resource is extracted through wells and boreholes. The quality of groundwater tends to degrade and also become scarce as the population of any geographical region increases. An increase in population invariably translates into building of more houses, wastewater facilities for disposal of domestic waste or sewage, and more generation of wastes.

Wastewater facilities are constructed in households for disposal of human wastes, wastewater from clothes washing machines, kitchens and bathrooms. The discharge of the sewage into soil overlying groundwater aquifers is often common in Nigeria and many developing countries which lack centralized sewage disposal systems. "On-site systems include ventilated improved pit latrines, pour-flush toilets and septic tanks(WHO 2006a)". outbreaks and septic tank systems (Craun, 1979, Bellers *et al.,* 1997; Borchardt *et al*., 2003b)". Bacteria and virus which are water borne can be transported along groundwater flow direction from source points to other areas down gradients of flow. "The work of De Borde *et al.* (1998) has demonstrated the movement of seeded virus through sandy aquifer for 9 months in the presence of viable seeds".

II. STATEMENT OF PROBLEM

Any urban development that practices on-site effluent disposal methods of domestic effluent treatment like septic tanks soil absorption system (ST-SAS) and pit latrines creates a risk to groundwater contamination (Mumma *et al;*2011). Groundwater is adjudged as a safe source of drinking water which is readily available to users, without analyzing its physico-chemical and bacteriological properties to see if the water is of good quality are almost a contest. However, it is a known fact that the attenuating soils beneath the earth crust generally act as filtration mechanism, thereby reducing the effect of micro-organisms, especially bacterial and protozoa. But groundwater pollution by micro- organisms, particularly the ones sited near wastewater facilities do occur. As at today, plot sizes being developed are small, hence more effluents from households, disposed through wastewater facilities and consequently a bigger threat to the sub-surface environment. Therefore, there is a need to assess the impact that wastewater facilities has on the quality of borehole water because the population in Ughelli depends on groundwater abstracted from boreholes in the area for drinking and domestic uses

AIMS OF STUDY

The aim of this research is to investigate the effect of siting boreholes and wastewater facilities in the same area onthe quality of groundwater in Ughelliof Delta State.

METHODOLOGY

i. Collect data using semi-structured questionnaires on boreholes and wastewater facilities in proximity to each other in the study area;
ii. Obtain samples from boreholes and investigate the physico-chemical and biological determinants on the quality of groundwater in the study area;
iii. measure the degree of contamination in groundwater contributed by wastewater facilities to the water table in the study area;
iv. ascertain the impact of the distance of constructed wastewater facilities on borehole water;
v. Compare the obtained results to WHO limits or standard.

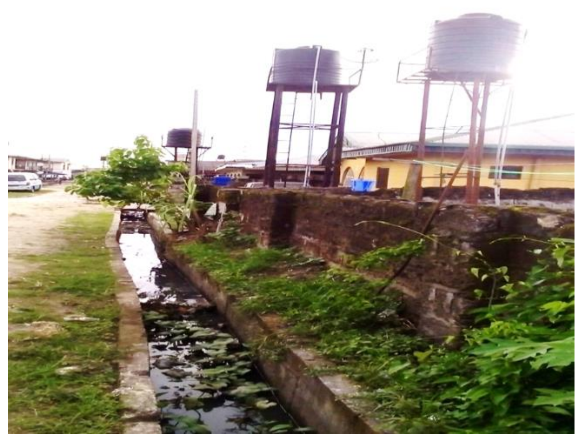

FIG 1.1

LITERATURE REVIEW

According to De (2010), "when the functions and qualities of water in its natural pure condition are not normal, then the water is said to be polluted". Water, that is of good quality is important to humans and is associated with their welfare. Pollution to natural water sources is mainly from domestic (rural and urban areas) and industrial waste being discharged therein (De, 2010). Water for domestic use, including drinking, should be within specific range of physical, chemical and biological parameters. These parameters have been reported, documented and accepted as a reference to ensure suitability of purpose and safety. Therefore, any deviation of parameters from the listed range of minimum and maximum contaminant levels will mean poor quality that is unsafe for consumption and would cause adverse effect on the health of the consumer, (Tables 2.1and 2.2) respectively. The water pollutants may be broadly classified as: organic, inorganic, sediments, radioactive materials, and thermal pollutants. Substances that contaminates water and results in pollution that is of organic nature are; oxygen demanding wastes, disease causing agents, plants nutrients, sewage, synthetic organic compounds and oil (De, 2010). The production and use of synthetic organic compounds would contribute to water pollution if not properly handled and disposed. These include; fuels, solvents, elastomers, detergents, paints, insecticides, food additives and pharmaceuticals, pesticides, chlorinated hydrocarbons, and detergents. These may find their way into groundwater reserves through leaching from on-site waste disposal systems. Surfactants (anionic, cationic and non-ionic), optical brighteners and builders (phosphate-based) cause water pollution problems. Inorganic pollutants consist of substances such as acids and salts that are derived from inorganic compounds, metals (lead, mercury, arsenic, selenium, chromium) in ionic or colloidal states in different compounds and polyphosphate in detergents. Ground water has been contaminated and polluted by anthropogenic activity that has being going on, increasingly over time without regards to the environmental consequences which eventually result in the deterioration of physico- chemical and biological properties of water (longeet al.,2010).sub-surface, on-site,methods of domestic effluent or waste water disposal are the main source of wastewater to the ground, and are most the most frequently reported causes of ground water contamination(Miller,1980)

METHOD OF TREATMENT

Aqua privies are essentially limited to single or few dwellings. Septic tanks and aqua privies operate by initial deposition of excreta into an impermeable tank with over flow of excess liquid in a soak away. In both technologies, the sludge is retained under water and this must be maintained to reduce offensive odours. “Septic tanks are usually located at a distance from the toilet and water is used to flush excreta into the tank(Lerner and Beret (1996)”. In this aqua privy, the tank is located just below or adjacent to the toilet. Water requirements are often lower than for septic tanks systems, but the tank requires periodic addition of water to ensure water seal is maintained. “Inside the tank of septic system and aqua privies, solids settle at the bottom of the tanks; a scum forms a crust on the surface. As the tank fills with liquid, the overflow is channeled out of the tank to the soak ways (WHO 2006b)”.

The destruction of pathogens via predation, attenuation and thermophilic or natural occurs in the tank and drainage field, but this may be incomplete especially for viruses. This may result from high flow rate which may reduce the potential for absorption. “Disease outbreaks associated with

Fig 2.1

Table 2.1: World Health Organization Drinking Water Quality

Substances	W.H.O Maximum Guideline Value
B.O.D$_5$(mg/l)	6.0
C.O.D (mg/l)	10.0
Ph	6.5 – 8.5
T.D.S	500
Elect. Conduct. (μs/cm) Total Hardness as	-
C_aCO_3 (mg/l)	100
Acidity (mg/l)	500
Alkalinity (mg/l)	500
Sulphate (mg/l)	250
Chloride (mg/l)	500
Fluoride (mg/l)	1.4
Nitrate (mg/l)	10 as N; 45 as NO_3^-
Bicarbonate (mg/l)	500

Carbonate (mg/l)	500
Calcium (mg/l)	200
Magnesium (mg/l)	150
Iron as Fe^{2+} (mg/l)	0.3
Manganese (mg/l)	0.1
Chromium (mg/l)	0.05
Sodium (mg/l)	200
Potassium (mg/l)	15
Zinc (mg/l)	5.0
Copper (mg/l)	1.0
Ammonia (mg/l)	0.5
Total bacteria count /100ml	10.0
e.coli /100ml	0.0

Source: WHO (2008)

Table 2.2: Nigerian Parameters and Maximum Allowable Limits for Drinking Water

Parameters	Unit	Maximum permitted	Health Impact
Aluminum (Al)	mg/l	0.2	Potential neuro-degenerative disorders
Arsenic (As)	mg/l	0.01	Cancer
Barium	mg/l	0.7	Hypertension
Cadmium (Cd)	mg/l	0.003	Toxic to the Kidney
Chloride (Cl)	mg/l	250	None
Chromium (Cr^{6+})	mg/l	0.05	Cancer
Conductivity	µS/l	1000	None
Copper (Cu^{+2})	mg/l	1	Gastrointestinal disorder
Cyanide (CN^-)	mg/l	0.01	Very toxic to the thyroid and the nervous system
Fluoride (F^-)	mg/l	1.5	Fluorosis, Skeletal tissue (bones and teeth) morbidity
Hardness (as $CaCO_3$)	mg/l	150	None
Hydrogen Sulphide (H_2S)	mg/l	0.05	None
Iron (Fe^{+2})	mg/l	0.3	Cancer, interference with Vitamin D metabolism, affects mental development in infants, toxic to the central and peripheral nervous systems
Lead (Pb)	mg/l	0.01	Consumer acceptability
Magnesium (Mg^{+2})	mg/l	0.20	Neurological disorder
Manganese (Mn^{+2})	mg/l	0.2	Affects the kidneys and central Nervous system
Mercury (Hg)	mg/l	0.001	Possible carcinogenic
Nickel (Ni)	mg/l	0.02	Cyanosis, and asphyxia (blue-baby sundrome) in infants under 3 months syndrome) in infants under 3 months
Nitrate (NO_3)	mg/l	50	Cyanosis, and asphyxia (blue-baby syndrome) in infants under 3 months
Nitrate (NO_2)	mg/l	0.2	None
pH	-	6.5 – 8.5	None
Sodium (Na)	mg/l	200	None
Sulphate	mg/l	100	None
Total Dissolved Solids	mg/l	500	None
Zinc (Zn)	mg/l	3	None
Total Coliform count	cfu/ml	10	Indication of faecal contamination

Source: NSDWQ (2007)

- Effects of Microbial Contaminants on Groundwater Quality

Groundwater quality can be influenced directly and indirectly by microbiological process, which can transform both inorganic constituents of groundwater. According to Matthess *et.al*; (1985), single and multi-celled organisms have become adapted to using the dissolved materials and suspended solids in the water and solid matter in the aquifer in their metabolism, and then releasing the metabolic products back into the water. There is practically no geological environment at, or near, the earth's surface where the pH condition will not support some form of organic life, (Chilton and West (1992)).

All organic compounds can act as potential sources of energy for organisms. Most organisms require oxygen for respiration (aerobic respiration) and the breakdown of organic matter, but when oxygen concentrations are depleted, some bacteria can use alternatives, such as nitrate, sulphate and carbon dioxide (anaerobic respiration). Chiroma (2008) stated that organisms which can live in the presence of oxygen (or without it) are known as facultative anaerobes. In contrast, obligate anaerobes are organisms which do not like oxygen. The presence or absence of oxygen is, therefore one of the most important factors affecting microbial activity, but not the only one. For an organism to grow and multiply, nutrients must be supplied in an appropriate mix which satisfies carbon, energy, nitrogen and mineral requirements (Foster and Hirata, R. (1988).

2.4.1 Effects of Rock Bearing Strata on Groundwater Quality

Atmospheric precipitation infiltration through the soil dissolves CO_2 produced by biological activity. The resulting solution of weak carbonic acid dissolves soluble minerals from the underlying rock. A second process operating during passage through the soil is the consumption by soil organisms of the oxygen which was dissolved in the rainfall. These reactions occur in the soil and the top few metres of the underlying rock. In temperate and humid climates with significant recharge, groundwater moves continuously and relatively rapidly through the outcrop area of an aquifer; hence contact time with rock matrix is relatively short. Readily soluble minerals will be removed, but insufficient contact time exists for less soluble minerals to be taken up. Groundwater in the outcrop area of aquifers is likely to be low in overall mineralization, with the natural constituents depending on the materials of the materials of which the rocks are made (Chilton, 1996).

2.5 Chemical Toxicology of Water

Under the Safe Drinking Water Act (USEPA, 2006), established Water Regulations for over 80 contaminants with the aim of bringing down their levels, in all drinking water, closer to recommendations in the Maximum Contaminant Level Goals (MCLGs) previously established by the USEPA . For nitrate, the MCL is 10 mg/L (ppm) as nitrogen. The basis of the action taken by the United States Environmental Protection Agency (USEPA), setting the MCL at 10 mg/l, was the occurrence of methemoglobinemia in infants under six months. The MCL reflects the levels at which this condition may occur (USEPA, 2006), Mitigation actions must be implemented so that the child should not become sick from methemoglobinemia. People, who live away from urban areas or in informal settlements, would be safer from this disease if their boreholes are routinely tested, especially if pregnant women or infants are consumers of the well water (USEPA, 2006).

2.6 Physico-Chemical and Biological Determinants.

In chemical analysis, substances that make water unpalatable at concentrations higher than the existing standards for proper health or that affect the look, smell, taste and that are of health concern, were investigated by WHO 2007. These investigations help to establish health-based summary statements and guideline values. These summary statements and guideline values for each substance, upon adoption by water authorities, aid in the provision and usage of water which is satisfactory aesthetically and has uniform quality (WHO, 2007). Bacteriological analysis investigates microbiologically, both quantitatively and qualitatively, microbial contaminants in the water. The importance of bacteriological analysis of drinking water helps to determine the presence of potential water-borne pathogens. Bacteriological analysis of water is the most sensitive quality parameter that determines groundwater contamination.

2.6.1 pH

pH (PondusHydrogenium), is the degree of the basicity or acidity of a water solution or simply as the measure of hydrogen ion concentration of a water solution [H]+. pH has no unit of measurement, since it is a dimensionless quantity, by virtue of its logarithmic nature. It is a parameter that determines the quality of all waters, which also affects most physical, biological and chemical processes in water supply treatment (WHO, 2007). Water, in its pure state, for example, has a pH of 7 (neutral); the exact values depend on temperature. For most natural waters, the pH ranges from 6 to 8.5, values below 7(acidic waters) in waters that are high in organic content and values above 7 (alkaline waters) in eutrophic waters, groundwater brines and salt lakes (USEPA, 2006). However, for clean water, the pH may be due to, among other reasons, the types of rocks and vegetation within the watershed (WHO, 2007). It is also a factor of great significance, since some methods or processes of water treatment, geared towards improving water quality can only take place when water has a certain pH, e.g., the reactions of chlorine take place only when the pH is between a value of 6.5 and 8. Major reasons for variations of pH in water are; industrial and domestic effluent and acid rain from atmospheric depositions. Respiration and photosynthesis of algae in eutrophic waters can also cause fluctuations of pH in water (WHO, 2007). The pH is a very technical parameter for the quality of water, even though it doesn't affect water consumption; it should be monitored at all stages of water treatment to ensure satisfactory water clarification and disinfection. Low pH values (less than 4), indicate that the water is corrosive and that it will tend to dissolve heavy metals such as lead and chromium and other substances that it interacts with. These heavy metals and other dissolved substances tend to become toxic when dissolved in water. The pH values that are greater than 8.5 (high pH), mean that the water is alkaline, and that it will tend to form scale on heating (APHA, 1994

III. MATERIALS AND METHODS

3.1 Description of the Study Area

The Ughelli metropolis (Figure 3.1) is located in Ughelli North of Delta state, South-South Nigeria.

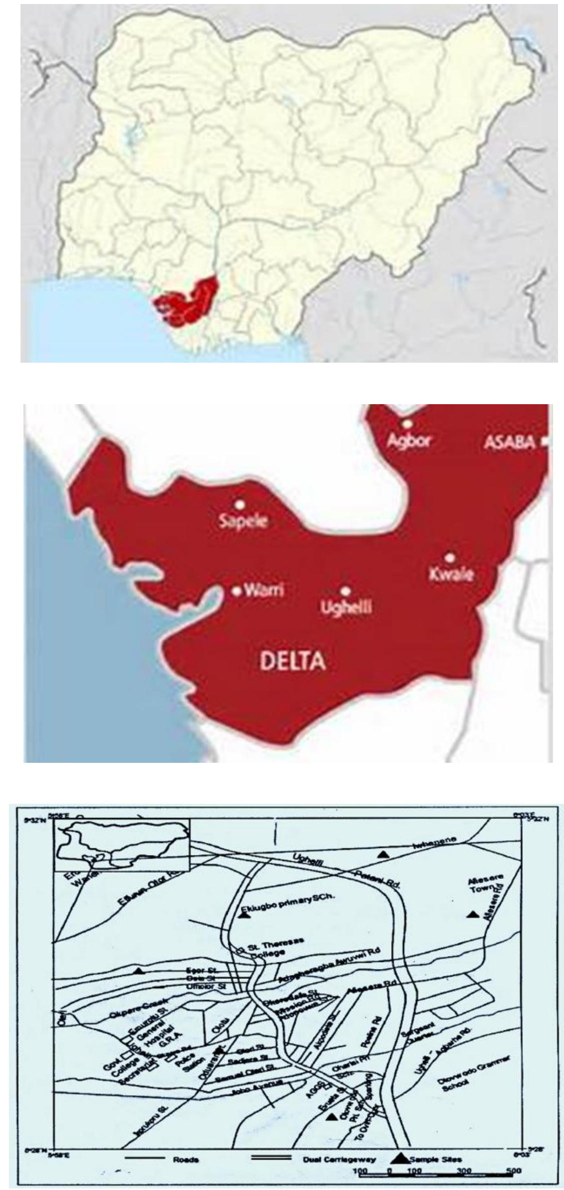

Figure 3.1: Map of Ughelli showing selected sample sites

3.1.1 Geographical Setting

The study area is situated in Delta central senatorial district and located between latitude 5^0 28'. 39.0"N and 5^0 28'. 30.5" E, and longitude 5^0 30'. 53" N and $6^0$01'. 04.5"E (Fig 3), which has two climate regimes; the dry season which spans from November to March and the wet season which lasts from April to October; the mean annual is above 2500mm with temperature that ranges from 20^0C to 34^0C; temperatures are usually higher during the day and lower at night. Relative humidity varies between 55% and 75% throughout the year. Vegetation of the area is typical of tropical rain forest region, which have been subjected to suffered quantum deforestation emanating from urbanization, sand dredging, farming and exploration of oil and gas activities.

3.1.2 Hydrology

The study area consists of unconfined, confined and semi-confined aquifers (Ohwoghere-Asuma 2013). They are very productive aquifers, high-yield characterized by high specific capacities, as well as high recharge rate. The static water level of the aquifers is very high; it often varies from less than 0.2 to 4 meters. The water fluctuates in accordance with the regimes of the seasons in a year (Ohwoghere-Asuma 2013). It is almost at the ground surface during the wet season as shown in Plate 3.1.; and decreases by one major river that flows through the season and, many streams that are perennial in nature, which flows during the rainy season and stagnation in dry season. These streams are part of wetlands and sometime contribute to the recharge of the aquifers. The aquifers are characterized by grain sizes that range from fine through medium to coarse grained sand. During the wet season, the static water level is almost at the well head (plate3.1) as a result of high water table in the study area.

3 Geological Setting

Ughelli is underlain by sequence of the known Niger Delta formations. The formations from the top to the base are Somebreiro-Warri Delta plain sands, Benin formation, Agbada formation and the Akata formation have been described in details by Allen (1965); Reyment,(1965) Short and Stauble, (1967); Weber and Dankuro (1975). The Warri deltaic plain sand is about 120metres thick and it is quaternary to Recent. Texturally, the unconsolidated sediments range from fine plastic clay-through-medium-coarse grain sands and rarely gravelly. The Benin formation consists predominantly of unconsolidated sand, gravel and occasionally intercalation of shale. It is a freshwater bearing formation in the Niger Delta region and it provides all the fresh water need of the people. It thickness is about 2000metres and varies from Oligocene in age. The Agbada formation is the oil bearing formation of the Niger Delta sedimentary basin. It is of Eocene to Nate sand, and shale sequence and about 3000metres thick. The Akata formation is the basal unit of the Niger Delta sedimentary basin and overlies the basement complex. This formation is highly pressured and compositionally it is made up of open marine faces. Its thickness is estimated to be 1000km and the age is from Eocene to Oligocene.

3.2 Reconnaissance Survey

Field visits were paid to the study area for site selection and survey (figure 3.1). Selection of physical, chemical and biological determinants to be determined were done (Table 3.0). Topographic map and data on water quality; information on borehole and wastewater facility was carried out. Topographic information was obtained with the aid of Global Positioning System instrument, Garmin GPS model 72H. Sampling sites and a cartographic map of sampled area was made (Figure 3.1). Also, contact with the borehole owners was achieved by issuing consent form to property owners in the study area to intimate them of the research and equally seek their permission and participation as well (Appendix A). Feasibility studies involving determination of the resource requirements; risk assessment, design of data collection techniques

Table 3.0: Sampling sites, elevation, GPS Coordinates.

Sites	Codes	Elevation (m)	Coordinates	Waste water facility dimension and area (L*B)	Location of borehole in relation to waste water facility
Afiesere road	BH 1 WWF 1	13.70 14.60	05^0 31.28'0 "N 06^0 02.30'5 " E	6m x 1.5m 9 m^2	Down slope at D ≤ 2.5m
Evueta street	BH 2 WWF 2	6.50 7.20	05^0 31.24'1 "N 06^0 02.11'2 " E	5m x 1.5m 7.5m^2	Down slope at D ≤ 5m

Egor street	BH 3 W WF 3	9.60 7.30	05^0 31.30'2 "N 06^0 02.16'7 " E	6m x 1.4m 8.4m^2	Up slope at D ≤ 7.5m
Ekiugbo Primary Schools	BH 4 W WF 4	8.20 6.40	05^0 31.26'8 "N 06^0 02.12'1 " E	4 m x 1.5m 6 m^2	Up slope at D ≤ 10.5m
Iwhenene	BH 5 W WF 5	6.70 4.10	05^0 30.9'27 "N 06^0 01.8'6" E	6 m x 1.2m 7.2 m^2	Up slope at D ≤ 12.5m

Source: field data

D = distance, BH- borehole, WWF – wastewater

Plate 3.1: High water level in a borehole during the wet season in the study area

3.2.1 Study Design

This was a cross-sectional study, a total of 125 questionnaires were administered but only 25 household owners responded. Others were not willing to participate because they share the belief that wastewater facilities effluents cannot interact with borehole water and out of fear that the government might sanction and condemn their boreholes if found contaminated.

3.2.2 Sample Size

This was calculated from total number of respondents, the number of households was assumed to have boreholes and wastewater facilities in Ughelli. To achieve this, the total number of households was divided by the sample size using the formula:

$$k= \frac{N}{n} \quad (1)$$

Where: k = sampling interval,

n = sample size

N = population size

Hence, k = 125/ 25

k = 5.

From the calculated value of "k" above the starting point was any number from 1 to 5 of the households of the respondents to the questionnaires. After the first number was picked, every 5th household was selected and 5 households were selected at the end.

3.2.3 Sampling Procedure

Sampling process was carried out by an expert in water analysis. Firstly, water samples were randomly collected in the morning hours in five identified boreholes sites (Figure 2) representing the study area at Ughelli. All boreholes from which water samples were collected had already been cased and functional for at least 5 years. The sampling was done in the dry season (April 2016) and peak of the rainy season (July 2016) respectively. The samplings were done according.

to APHA (1994) standard. To avoid possible source contamination each tap was sterilized by a flame from cotton wool soaked in methylated spirit, lit with a lighter as

3.4 Domestic Wastewater Facility Distance from Borehole Measurement:

The distance from selected boreholes and wastewater facilities were taken using a measuring tape and sites that were chosen due to the fact that their distances lies within 2.5m≤D≤12.5m and accessibility, proximity of wastewater to borehole (Plates 2.1, 2.2 & 3.1) respectively.

3.5 Laboratory Analysis

The water samples were taken for analysis in a certified water laboratory in Delta state, Nigeria. The analysis was done in accordance with APHA 1995. The physical parameters determined are appearance, pH, electrical conductivity, TDS, and turbidity while the chemical parameters determined are nitrates, sulphates and ammonia respectively. The biological parameters determined are total coliform bacteria, and e-coli.

3.5.1 Physical Parameters

Detail of the laboratory analysis of each physical parameter is/are discussed below.

3.5.1.1 Temperature

About1.5 litres of sample were collected in a plastic bowl and the temperature was measured in accordance with APHA 1995.

3.5.1.2 pH

A pocket-sized pH Meter was calibrated by immersing the tester up to the maximum level in a buffer solution (HI7007) with pH 7. As the reading stabilizes, the reading was read and recorded with an accuracy that reads within +/- 0.1 pH value. 50 ml of the sample was drawn into a beaker and placed on a water bath at 25^0C. The instrument was immersed in the sample with the sensing electrode up to the maximum immersion level, and was stirred gently, then waited until the display stabilized before taking the reading.

3.5.1.3 Turbidity

Horiba Water Checker (Model U-10) was used to measure the turbidity after calibration with standard Horiba solution.

$NH_3 + HgI4^{2-} + 3OH^- \rightarrow NH^2Hg^2IO + 7I^- + 2H_2O$ (orange-brown)

Spectrophotometer was used to measure the orange-brown at 420 nm.

3.5.2.4 Biochemical Oxygen Demand

For Bio-chemical Oxygen Demand determination, water sample was incubated at 20^0C for at least five days. The samples suspected of BOD were diluted before incubation, to ensure presence of oxygen and the BOD_5 calculated using the following equation (Ayotamuno, *et al*., 2007.)

$$BOD_5 = (A - B) \times D_f \quad (2)$$

Where: A = initial DO of dilution water,

B = DO after 5-day incubation and;

D_f = dilution factor of sample to dilution water.

3.5.2 Biological Parameters

Details of the laboratory analysis of each biological parameter are discussed below.

3.5.2.1 Escherichia Coliform

The culture medium for incubating Escherichia coliform was made from a mixture of 10g peptone, 10g lactose, 2g KH_2PO_4, 15g agar, 4g eosin Y and 0.065g methylene blue in 1 litre distilled water of pH 7.1 after sterilization. 0.1 ml of water sample was incubated in the culture media on a membrane at 37 ± 1^0C for 48 hours and the number of coliform colonies were counted and expressed as colony counts per 100ml of water sample.

3.5.2.2 Total Coliform

Mix 5g tryptone, 3g beef extract, 1g glucose and 15g agar in 1 litre of distilled water of pH 6.8 – 7.0 after sterilization to serve as the culture medium for incubating the total bacteria. 0.1 ml of water sample was incubated in the culture media on a membrane at 35 ± 0.5^0C for about 48 hours. The number of bacteria colonies were counted and expressed as colony counts per 100 ml sample.

3.6 Data Analysis

The results obtained were represented by the use of statistical tables, text and graphs to show the interrelationship between the various variables such as pH, total dissolved solids, turbidity, electrical conductivity, nitrate etc, on the water quality determinants.

IV. RESULTS AND DISCUSSION

4.1Questionnaires Analysis

A total of 125 questionnaires were administered but only 25 household owners responded out of fear that the government might condemn their boreholes if found contaminated. From the questionnaires, 100% of the residents do not know the quality of water they consume from their borehole; 25% of the residents installed water filter; while 75% do not carry out any form of treatment before consumption. 85% do not agree that there could possibly be a direct link between a wastewater facility and a borehole that may impact water quality even if they are sited close to each other while 15% agrees that there could be interaction of septic effluents in their borehole water. During construction of wastewater facility 100% incorporated drain opening beneath the structure. Permission was granted to access boreholes and wastewater facilities for sampling.

4.2 Domestic Wastewater Facility Distance from Boreholes

Sampling sites were selected based on the fact that wastewater facility and borehole were sited within a distance of ≤ 12.5m from each other and accessible easily. The horizontal distance measurements of wastewater facility close to sampled borehole is shown in Table 4.1. Static water level and depth of boreholes data of sampled site is/are also shown in Table 4.1. While depth of wastewater facilities was obtained from the property owners.BH1 and BH2 have the highest depth of 30.0m and wastewater facility depth of 3.5m and 3.0m respectively. While BH5 has a depth of 27.0m with a wastewater facility depth of 2.74m sited close to it. The borehole sited closest to wastewater facility is BH1 at a distance of ≤ 2.5m while BH5 was furthest (Figure 4.1).

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

This study provided data on the parameters previously analyzed at the time of drilling, static water levels, borehole depths and wastewater facilities distance for five selected boreholes sampled. The research work shows that the water in all the boreholes in the selected area of study is acidic as indicated by the pH values both in dry season and wet season respectively. This is of a major concern because the health of people drinking water from such boreholes is at risk. Hence, water from all the boreholes in the study area is unpalatable for drinking. Besides, when septic tanks are sited close to a borehole(s) (2.5 – 12.5 m), the impact of the contamination levels is higher during the wet season due to the increased amount of groundwater recharge which results in soil saturation and consequently resulting in reduced filtration. Domestic wastewater facilities are sources of traceable nitrates, ammonia, sulphates, total coliform bacteria, and E.coli in borehole water in Ughelli.

The septic tank systems did not have effect on the pH values on the borehole water. The borehole (BH1) sited at a horizontal distance≤2.5 m to septic tanks, had highest TDS and turbidity level. Septic tank systems are sources of nitrates, ammonia, sulphates and E.coli to borehole water in both seasons.

The result reveals that parameters such as turbidity and total dissolved solids, and sulphates have no significant variation in all the sites and are not necessarily an impact of the septic tank distance location. Furthermore, the presence of NO^{3-}, NH_4^+, and BOD_5 can be used as tracer with relation to leachates percolation. As there is no natural or other possible reason for the presence of these pollutants, it can be concluded that leachates has significant impact on BH1, and BH2 in Ughelli.

The effect of septic tank distances have been confirmed since the concentration of the pollutants reduces with longer distance from the septic tank systems at ≤2.5m, and the pollution levels were higher in wet season. BH1and BH 2, water samples are not within WHO (2008) drinking water standards for E.coli, ammonia, and have marginally high levels of nitrates, and TDS and therefore the most polluted borehole sites in Ughelli.

Recommendations

1. The acidic nature of the water in these areas must be treated by the use of pH correction filter or use of neutralizing media before consumption. Also calculated amount of lime should be added to the borehole water at some specific intervals to make it alkaline.
2 The determination of pollutants levels in other boreholes in Ughelli should be conducted, so as to get more accurate analysis reports, on septic tanks distances and concentrations and quality of effluent being discharged from septic systems.
3. There is the need for the environmental assessment to include aspects of subsurface environments and groundwater when constructing domestic on-site effluent treatment and disposal facility.

4. Efforts should also be made by the regulatory agencies such as Environmental Management Personnel and local government to meet and enforce the international standards and recommendations for the location of onsite effluent disposal systems.
5. Other pollution levels of heavy metal ions levels in water samples from boreholes close to septic tanks in Ughelli should be analyzed.
6. The contaminated boreholes (BH1 and BH2) should be treated and disinfected (i.e chlorination)due to presence of e.coli and suspected pathogens before consumption.

REFERENCES

[1] Adelekan B.A. (2010). Water quality of domestic wells in typical African communities: Case studies from Nigeria. Int. j. water Res. Environ. Eng. 2(6): 137-147, Vol8 (30), pp. 15581, 16 August, 2013 DOI: 10. 5897/IJPS2013.3920INSS

[2] Allen J.R.L, (1965). Late Quaternary Niger Delta and Adjacent areas: sedimentary environments and lithofacies Bull. AAPG 49, 547 – 600

[3] APHA (1994) Standard Methods for the Examination of Water and Wastewater, 15th Eds. APHA-AWWA-WPCF Washington DC, USA, 66, 73,101,112.]

[4] APHA (1995) Standard Methods for the Examination of Water and Wastewater, 18edition. APHA-AWWA-WPCF Washington DC, USA.

[5] Ayotamuno M.J. and Kogbara R.B (2007). Response of Environmental Characteristics to Industrialization: A case study of the Onne oil and Gas Free Zone, Nigeria. J. of Food agriculture and Environment. Vol.5 (1) 288 -289.

[6] Banda LJ, Mbewe AR, Nzala SH, Halwindi H (2014). Effect of Siting Boreholes and Septic Tanks on Groundwater Quality in St. Bonaventure Township of Lusaka District, Zambia. Int. J. Environ. Sci. Toxic. Res. Vol. 2(9):191-198

[7] Bellers, M, Ellis, A., Lee, S.H., Drebot, M.A.,Jenkerson, S,A., Funk, E., Sobsey, M.D., Simmons III., O.D., Monroe, S.S., Ando, T., Noel, J., Petric, M., Middaugh, J.P., Spika, J.S., (1997). Outbreak of viral gastroenteritis due to contaminated well: International consequences. Journal of the American Medical Association 278(7), 563-568.

[8] Borchardt, M.A., Chyou, P., Device, E.C, Belongia, E.A, (2003), Septic system density and infections diarrhea in a defined population of children. Environmental Health perspectives III (5), 742 – 748.

[9] Brown, CL, Starn J.J, Stollenwerk, K.Mondazzi R.A. Trombley, T.J. (2009). Aquifer Chemistry and Transport processes in the zone of contribution to a public supply well in Woodburg.