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Effects of Septic Tank on the Quality of Groundwater from Hand-Dug Wells in Effurun, Delta State, Nigeria

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Abstract— *In modern day Nigeria, there are boreholes and pipe born water, which cost a fortune to put in place. Common man had to resort to digging wells as the only cost effective alternative source of drinking water and for daily domestic purposes. This study was aimed at determining the effects of septic tank on the quality of groundwater from hand dug wells. Water samples were collected in ten hand-dug wells spread within Effurun and analyzed for pH, Temperature, Electrical Conductivity, Total Dissolved Solids, Turbidity and Faecal coliform. The results indicated a pH in Location A (6.60), locations B, C, D, E, F, G, H, I and J (5.20 - 6.40), Temperature (28.0oC - 30.0oC), Electrical Conductivity in locations A, B, E, H and I, (430 – 720 µS/cm), locations C, D, F, G and J (260 – 380 µS/cm), Total Dissolved Solids (204.8 mg/l to 2816 mg/l), Turbidity in all the ten locations (2.00 -6.00 NTU), locations C and I (6 NTU), Faecal Coliform all the ten locations indicated the presence of faecal coliform (10.70 -29.00 cfu/100ml). It was concluded that there was possible contamination from septic tank due the proximity to the hand dug wells, as the distances between Wells and the septic tanks failed short of the minimum recommended distance of 50ft, couple with the fact that some of the Wells do not have covers. The water from all the ten wells in the ten different Locations is not portable; hence it raises serious public health concerns to the residents of these areas. Boiling of water before use is highly recommended to eliminate faecal coliform.*

Keywords— *Effects, Septic Tank, Quality, Groundwater, Hand- Dug, Wells.*

I. INTRODUCTION

Long before the advent of boreholes, hand-dug wells, streams, ponds, rainfall and rivers were the main sources of drinking water to the populace in a country like Nigeria. In modern day Nigeria, there are boreholes and pipe born water in some areas due to development, though not sufficient. But due to slow nature of development, economic capabilities and increasing population growth, the boreholes and pipe born water is either not sufficient or not affordable to common man. Hence, the common man had to resort to digging wells as the only alternative source of water for drinking and for daily domestic and commercial purposes.

Site-specific conditions and local groundwater flow are often ignored when installing septic systems and wells. In areas with small lots (thus high spatial septic system densities), shallow domestic wells are prone to contamination by septic system leachate. Specifically, we determine the probability that a source area overlaps with a septic system drain field as a function of aquifer properties, septic system density and drain field size. It was shown that high spatial septic system density poses a high probability of pumping septic system leachate. The hydraulic conductivity of the aquifer has a strong influence on the intersection probability. They found that mass balance calculations applied on a regional scale underestimate the contamination risk of individual drinking water wells by septic systems. This is particularly relevant for contaminants released at high concentrations, for substances that experience limited attenuation, and those that are harmful even at low concentrations (Bremer and Harter, 2012).

Septic systems can contaminate ground water with dissolved solids, nitrate, anoxic constituents (manganese, iron and hydrogen sulfide), organic compounds, and microorganisms. There is a widespread misperception that nitrate is a universal indicator of ground-water contamination by sewage. Chloride and stable isotopes are used to geochemically fingerprint the impacts of septic systems versus other sources of ground-water contamination. Ground-water nitrate originating from septic systems and primary sewage-treatment plants is enriched with ^{15}N due to biological fractionation. If ground-water de-nitrification occurs during migration away from any nitrate source area, ^{15}N enrichment will occur. Septic effluent discharged below the ground surface is not subject to the evaporative enrichment of ^{18}O that can occur in wastewater ponds, and this is reflected in the isotopic composition of ground water impacted by these sources (McQuillan, 2004).

Sewage is the primary source of pathogenic microbial contamination of ground water as it is in surface water. The situation of sewage contamination is worsening due to the unsafe method of sewage system construction and the shallow depth of water table. Wastewater in rural areas of Upper Egypt is disposed and collected into an underground sewage room. The sewage room in rural areas is constructed to be in direct contact with ground water. Hand pumps, 17 m deep, and wells, 50 m deep are used to supply drinking water in rural areas. The shallow depth of hand pumps and high capacity of wells is likely to create a susceptible condition of rural water supply. However, detection of pathogenic bacteria such as fecal coliform in the hand pump and well water provides an indication of biological contamination from sewage system (Abdel-Lah and Shamrukh, 2001). pH value is a good indicator of whether water is hard or soft. The pH of pure water is 7 (neutral). In general, water with a pH lower than 7 is considered acidic, and with a pH greater than 7 is considered basic. The normal range for pH in surface water systems is 6.5 to 8.5, and the pH range for groundwater systems is between 6 to 8.5 (www.freedrinkingwater.com).

On-site wastewater treatment systems (OWTS) work by first storing the wastewater in a septic tank before releasing it to soils for treatment that is generally effective and sustainable. However, it is not clear how the abundance of *E. coli* changes during its passage through the tank. They collected wastewater samples at the inlet and outlet of an experimental septic tank in addition to obtaining water samples from lysimeters below trenches where the drainpipes were buried. It was reported that *E. coli* concentration was higher by 100-fold in the septic tank effluent than influent wastewater samples, indicating the growth of *E. coli* inside the tank under typical Georgian summer weather. Electrical conductivity, pH and nitrogen were similar between the influent and effluent wastewater samples. *E. coli* and total coli form concentrations were mainly below detection in lysimeter samples, indicating the effectiveness of the soil in treating the wastewater (Appling et al., 2013). Putri et al., (2013) conducted a research to know the quality of groundwater of that it was conducted the research indicated by the existing of feacal Coli form and concentration of Fe and Mn based on complains by most of Ciracas society. Microbial and chemical data were collected at each sites from 15 wells with three replications from 5 villages as sites of sampling (Ciracas, Susukan, Kampung Rambutan, Kelapa Dua Wetan, and Cibubur Bekasi) and analyzed. The results showed that most of the groundwater surrounding Ciracas sub-district had been contaminated by *Coli form* and *Escherichia coli* ranging from 0 to 26.000 MPN/100 ml and 0 to 6790 MPN/100 ml, excluded Susukan village which was used to rice field, and this was significantly different at study sites in each land uses ($p<0.05$). Their study revealed high amount of Fe in the swamp sites, more than 0.3 ppm and for the used to rice field showed less amount of Mn (< 0.1 ppm). They inferred that most of groundwater in Ciracas sub-district was not able to be used as drinking water. It is needed pre-treatment to drinkable. The study of Water quality of domestic wells in typical African Communities by Adelekan, (2010), revealed that there was ionic dominance pattern of Na > Ca > Mg and HCO3 > Cl > SO4, indicating typical cationic characteristics and anionic characteristics of groundwater. Generally, the levels of nitrate, sulphate, chloride, trace elements (e.g. manganese and iron) were moderately high, indicating organic contamination of the groundwater but the WHO guidelines were not exceeded. Guidelines for microbiological quality were met in several cases and the physical guidelines for colour, odour and taste were met in most cases. In urban areas, groundwater quality is determined by the geology and geochemistry of the environment, rate of urbanization, industrialization, landfill/dumpsite leachates, heavy metals, bacteriological pollution, and effect of seasons (Ocheri et al., 2014). Generally speaking, there is high microbial risk in drinking water that is contaminated with faeces from humans or animals, which can be a source of pathogenic bacteria, viruses, protozoa and helminthes. Pathogens derived from faeces are the major concern in establishing health-based targets for microbial safety. Microbial water quality usually varies rapidly and for a wide range. Short-term highs in pathogen concentration may increase disease risks considerably and may trigger outbreaks of waterborne disease (WHO, 2011). Faecal coliform bacteria are a subgroup of coliform bacteria that were used to establish the first microbial water quality criteria. The ability to grow at an elevated temperature (44.5 ^{o}C) separates these bacteria from the total coliforms and makes it a more accurate indicator of fecal contamination by warm-blooded animals. Fecal- coliform bacteria are detected by counting the dark-blue to blue-grey colonies that grow on a 0.65 micron filters placed on mFC agar incubated in a 44.5 ^{o}C oven for 22-24 hours. The presence of fecal coliforms in water indicates that fecal contamination of the water by a warm-blooded animal has occurred, however, recent studies have found no statistical relationship between fecal coliform concentrations and swimmer-associated sickness (www.water.usgs.gov/edu/bacteria.html).

Turbidity is the measure of relative clarity of a liquid. It is an optical characteristic of water and is an expression of the amount of light that is scattered by material in the water when a light is shined through the water sample. The higher the intensity of scattered light, the higher the turbidity. Material that causes water to be turbid includes clay, silt, finely divided inorganic and organic matter, algae, soluble coloured organic compounds, and plankton and other microscopic organisms. High concentrations of particulate matter affect light penetration and productivity, recreational values, and habitat quality, and cause lakes to fill in faster. In streams, increased sedimentation and siltation can occur, which can result in harm to habitat areas for fish and other aquatic life. Particles also provide attachment places for other pollutants, notably metals and bacteria. For this reason, turbidity readings can be used as an indicator of potential pollution in a water body **(**water.usgs.gov/edu/turbidity.html**).** Turbidity is a measure of water clarity how much the material suspended in water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. These materials are typically in the size range of 0.004 mm (clay) to 1.0 mm (sand). Turbidity can affect the colour of the water (www. /archive.epa.gov/). Turbidity has no health effects. However, turbidity can interfere with disinfection because the particles can act as shields for viruses and bacteria and provide a medium for microbial growth. Turbidity may indicate the presence of disease causing organisms. These organisms include bacteria, viruses, and parasites that can cause symptoms such as nausea, cramps, diarrhea, and associated headaches (www.freedrinkingwater.com). TDS represents the total concentration of dissolved substances in water. TDS consists of inorganic salts, as well as a small amount of organic matter. Examples of inorganic salts that can be found in water include calcium, magnesium, potassium and sodium, which are all cations, and carbonates, nitrates, bicarbonates, chlorides and sulfates, which are all anions. These minerals can originate from a number of sources, both natural and as a result of human activities (www.safewater.org).

Temperature has a considerable impact on biological activity and growth. Temperature controls the types of organisms that can live in rivers and lakes. Fish, insects, zooplankton, phytoplankton, and other aquatic species all have an ideal temperature range. As temperatures get too far above or below this ideal range, the number of individuals of the species decreases until finally there are none. Temperature also influences water chemistry. The rate of chemical reactions generally increases at higher temperature. Water, particularly groundwater, with higher temperatures can dissolve more minerals from the rocks it is in and will results in a higher electrical conductivity. The temperature of stream water can affect aquatic life in the stream. Warm water holds less dissolved oxygen than cool water, and may not contain enough dissolved oxygen for the survival of different species of aquatic life. Some compounds are also more toxic to aquatic life at higher temperatures (www.water.usgs.gov/edu/temperature.html).

In some places, the land allocated for residential purpose are either too small to accommodate the minimum distance required between a septic tank and source of groundwater or the people are unaware of such minimum distance. This study was aimed at determining the effects of septic tank on the quality of groundwater from hand dug wells.

II. MATERIALS AND METHODS

The methods described in APHA (1992) in conjunction with Guidelines for drinking-water quality second edition volume 3 (WHO 1997) were used in the analysis of physico-chemical and bacteriological parameters like pH, electrical conductivity, total dissolved solids, turbidity, temperature and coli form.

III. RESULTS AND DISCUSSIONS

pH

The pH of water samples collected in the ten locations of the study area ranges from 5.20 to 6.60. The pH of nine locations (B, C, D, E, F, G, H, I and J) revealed a range of 5.20 - 6.40 which is an indication of acidic water. Location J has the lowest pH of 5.20 which implies the highly acidic water the well located just 5.10 m from a septic tank. Location A has a pH of 6.60 which falls within the WHO limit of 6.5 - 8.5 and is the farthest distance from the septic tank (10.50 m). The acidity of water samples from the nine locations poses great danger if consumed by humans and can cause health problems such as acidosis which could have adverse effects on the digestive and lymphatic systems of humans (Nkansah et al., 2010).

TABLE I. Results of Water Samples Analyzed and the Distance from Septic Tank.

S/N	Sample ID	pH	Temperature (^{0}C)	EC (μs/cm)	TDS (mg/l)	Turbidity (NTU)	Coliform (cfu)	Well Distance From Septic Tank (m)
1	A	6.60	28.80	580.00	371.20	4.00	10.70	10.50
2	B	5.80	28.50	430.00	275.20	4.00	11.00	9.30
3	C	6.20	30.00	380.00	243.20	6.00	15.00	9.30
4	D	5.50	28.20	320.00	204.80	2.00	15.50	7.80
5	E	6.10	28.60	720.00	460.80	4.00	14.50	7.50
6	F	5.70	29.20	260.00	166.40	4.50	17.50	7.50
7	G	6.20	29.00	340.00	217.60	3.00	19.00	6.90
8	H	6.40	28.40	440.00	2816.00	5.00	21.00	6.00
9	I	6.30	29.90	680.00	435.20	6.00	27.00	5.70
10	J	5.20	28.00	350.00	224.00	3.50	29.00	5.10

Temperature

The temperature of water samples in all the ten locations in the study area ranges from as low as 28.0^{o}C to as high as 30.0^{o}C. All the values were within permissible limit of WHO (30^{0}C).

Electrical Conductivity (EC)

The electrical conductivity of water samples in locations A, B, E, H and I, ranges from 430 – 720 µS/cm. These values were higher than the WHO limits of 400 µS/cm. Whereas Locations C, D, F, G and J have electrical conductivities ranging from 260 – 380 µS/cm, which were below the WHO limits (400 µS/cm). Higher electrical conductivity values could be due to the distance between septic tank and water wells. All the wells closer to the septic tank returned higher values of electrical conductivity (Abila et al., 2012).

Total Dissolved Solids

The total dissolved solids of water samples collected in ten locations of the study area, ranges from as low as 204.8 mg/l to as high as 2816 mg/l (Table I). The values of TDS recorded in locations B, C, D, F, G and J were rated Excellent, locations A, E, and I were rated Good. Location H was the only location with highest value of about 2816 mg/l rated as Unacceptable according to (Table II).

TABLE II. Total Dissolved Solids Ratings according to WHO Standards.

SN	Level of TDS (m/l)	Rating
1	Less than 300	Excellent
2	300 – 600	Good
3	600 – 900	Fair
4	900 – 1200	Poor
5	Above 1200	Unacceptable

(Source: WHO, 1996)

Turbidity

The turbidity of the water samples in all the ten locations of the study area ranges from 2.00 -6.00 NTU. Locations C and I have the highest values of Turbidity of 6 NTU, which is higher than WHO limit. The remaining locations A, B, D, E, F, G, H and J were within the WHO limits of 5.00NTU.

Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces

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the amount of light penetrating the water, which reduces photosynthesis and the production of DO (www.archive.epa.gov/water/).

Faecal Coli Form

All the water samples collected in all the ten locations indicated the presence of faecal coliform. The highest was Location J with 29.00/100mL CFU which was the closest to septic tank at a distance of 5.10 m. While the lowest was Location A with 10.70/100mL CFU which was the farthest from a septic tank at a distance of 10.50 m. This could be as a result of contamination from the septic tanks and some of the wells do not have covers. This result is in conformity with the results obtained by Abdel-Lah and Shamrukh (2001), in which the detected faecal coliform in the ground water of all hand pump samples and to a less degree in deep wells water. The distance of hand pump location from the sewage room has a clear impact on the level of fecal contamination. Periodical biological examination of wells water is recommended to insure their safety.

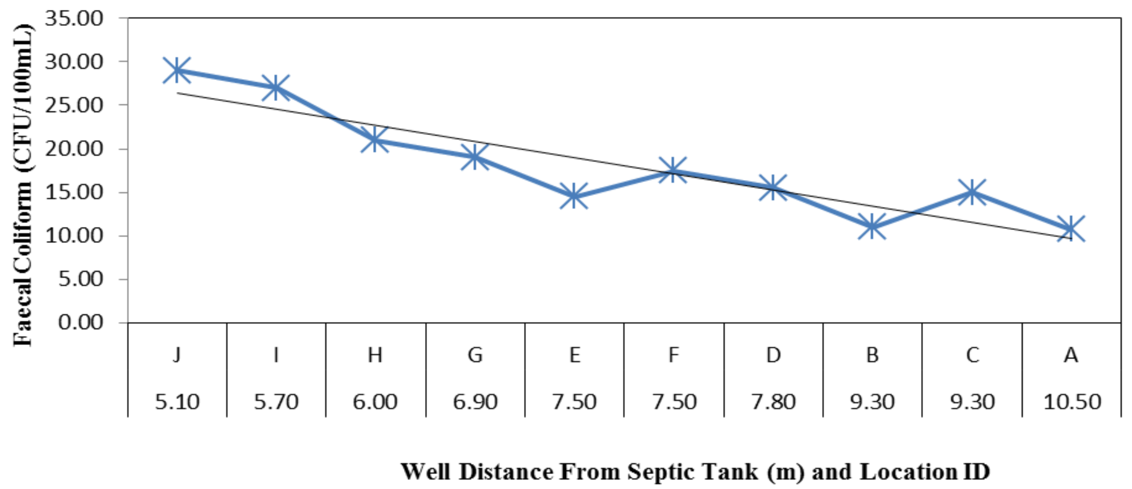

Figure I: Relationship Between Faecal Coliform and Well Distance from Septic Tank

The results compares well with the results obtained by Oluwasola *et al.*, (2017) in which they inferred that the water well with the least distance of 2.74 m was found to contain high coliform count and *Escherichia coli*, despite the fact that it is always covered, hence, the closeness of a well to septic tank may imply a higher tendency for contamination, therefore a considerable distance well above 15.24 m amongst other factors, will be essential for standard quality domestic well water.

Septic tank or pit latrines at distances of between 5.0±1.6 m and 7.3±1.2 m could account for the presence of E. coli in shallow wells from the two estates. Owing to the fecal contamination, there is a high possibility of the presence of disease pathogens in the water. The presence of E.coli, Vibrio, Listeria and Salmonella sp. not only makes the water unsuitable for human consumption, but also poses serious health concerns (Abila et al., 2012). This is in agreement with the distances between septic tanks and wells in this study (5.10 m to 10.50 m). Coli form also enter water in individual house well via backflow of water from a contaminated source, carbon filters or leaking well caps that allow dirt and dead organisms to fall into the water (Nkansah et al 2010).

IV. CONCLUSION

The results obtained in this study suggest possible contamination from septic tank due the proximity to the hand dug wells, as the distances between Wells and the septic tanks failed short of the minimum recommended distance of 50ft, couple with the fact that some of the Wells do not have covers.

The bacteriological quality of hand dug wells in all the ten Locations are very poor indicating faecal coliform in all. The pH in all but one of the Locations was acidic. Electrical conductivity of five (50%) of the Locations were very high above the WHO guidelines. TDS in six Locations was excellent, good in three Locations and unacceptable in one Location. Turbidity was within the WHO limits in eight out of ten of the Locations. Generally speaking, the water from all the ten wells in the ten different Locations is not portable; hence it raises serious public health concerns to the residents of these areas if consumed.

Boiling of water before use is highly recommended to eliminate faecal coliform.

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