Investigation on Pollution Level of a Private Shallow Well in Ifite-Awka, Nigeria

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Abstract- The study presents the pollution level of a private shallow well in Ifite-Awka, Anambra state Nigeria. In this community, a privately owned well that was poorly constructed was monitored to ascertain its pollution level at two different seasons. The well is at close proximity to a septic tank at a distance of 5.1meters with a leaking inspection chamber installed on a pavement that is higher and adjacent to the pavement of the shallow well. Water samples were collected from this well weekly for two months each in two different seasons (which are dry season and raining season). A total of sixteen samples were collected and analysis for pH, total hardness, chloride, nitrate, total dissolve solid, turbidity, total coliform and E. coli. Pollution index and correlation matrix were used to analyzed the data obtained. The result showed that water quality of the well varies season by season. E coli was detected in all the water samples which indicates that the water is strongly and seriously polluted during dry season and raining season respectively.It was recommended that the well should be properly lined, grouted and located to protect its water quality.

Indexed Terms- pollution level, shallow well, pollution index, well location

I. INTRODUCTION

A private well is a well that is privately owned and provides water to a single building and does not provide water to the public through a commercial or social activity. The most common problem associated with private wells is poor well location (https://www.epa.ie/water).For a well to be constructed appropriately, there are also recommended setback distances between polluting activities and private well which will assist in protecting well from contamination. A well should be located at least 15 m (50 ft.) from any source of contamination if the casing is watertight to a depth of 6 m (20 ft.); otherwise, the separation distance should be at least 30 m (100 ft.). Sources of contamination include: septic systems, manure storages, fuel storages, agricultural fields (manure or fertilizer runoff), and roads (salt runoff) (http://www.omafra.gov.on.ca). Researchers have shown that most of the bacteria, viruses, parasites and fungi that contaminate well water come from faecal material from human and other animals. The presence of these micro-organisms in drinking water sources may provide an indication of water-borne problems and is a direct threat to human health and is a matter of serious concern.

In Anambra State, the awareness of waste pollution is quite low; thus, tapping underground water through shallow wells sometimes very close to septic tank is somehow not uncommon. In Ifite Awka community, there is a rapid growth in population. This is because, apart from local occupants, many hostels have been built and are largely occupied by students of Nnamdi Azikiwe University Awka. For the fact that there is no central waste-water treatment system in the town, every landlord or house owner is therefore compelled to installed septic tanks and soak away, in order to dispose of the domestic waste waters. It is not uncommon to see landowners maximized a plot of land (with dimension 100 by 100feet) by positioning of eight flats (four flats erected opposite each other) in order to generate more revenue from house rate. These land owners also install two separate septic systems and two separate shallow wells in order to obtain potable water for each flat all in the same plot of land. However, in a desperate effort to achieve their target, these land lords/house owners have drilled shallow wells to tap the ground waters, without taking cognizance, the distances of these shallow wells from septic tanks and soak-away

(Fubara-Manuel and Jumbo, 2014). Most groundwater from home wells- even the deepest ones comes from within a few miles away. The shallowest well pump up water that originate from the household backyard.https://polk.extension.wisc.edu

In many instances septic tanks and soak-away pits are closer to shallow and deep wells than the World Health Organization (WHO) standard safe distance of 30m-40m. Besides, boreholes are drilled to depths shallower than United Nations Children Fund (UNICEF) standard of 100m-150m (Eze and Eze, 2015). This scenario makes groundwater vulnerable, particularly by leachates and flooding. Another possible situation is contamination from leaking inspection chamber. This typical scenario was sited at Ifite-Awka where the inspection chamber is installed on a pavement that is higher and adjacent to the pavement of a shallow well (Figure 1). The contamination of the shallow well water is determined by two factors which includes sewage leakage from the inspection chamber and a well cover that is not water tight. These wells therefore become potential pathway for contaminants to enter ground water. This can serve as a vehicle for spreading diseases/illness caused by such micro-organism.

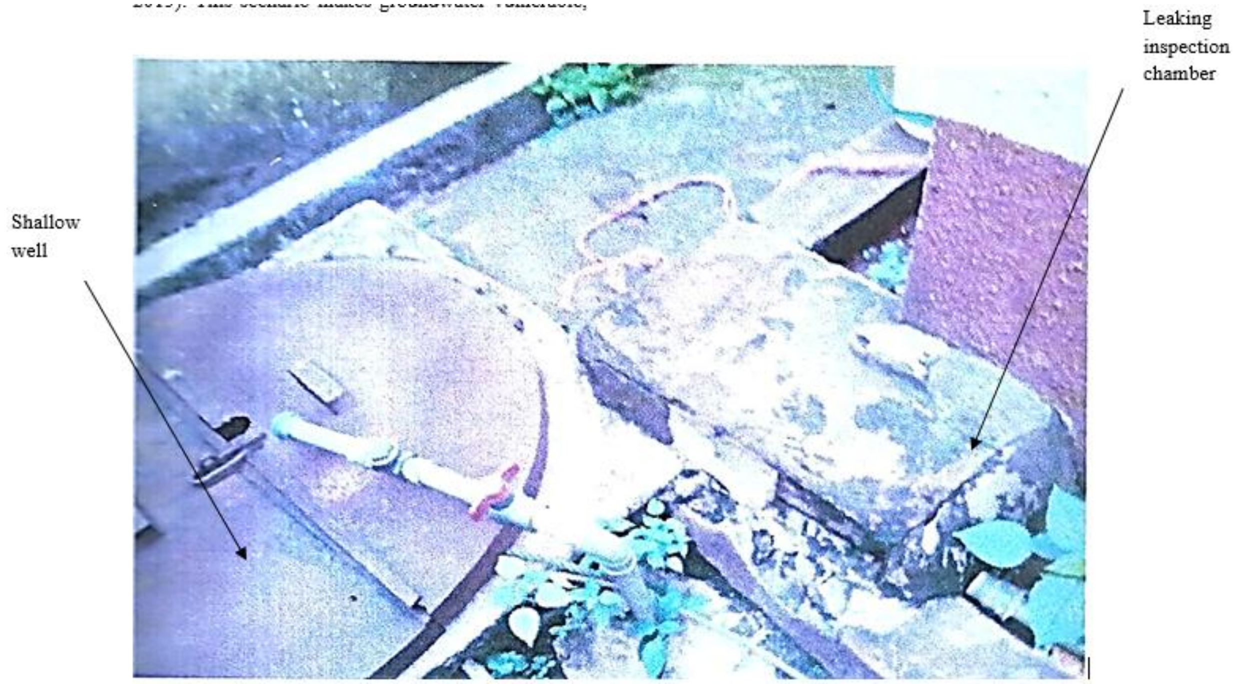

Figure 1: A shallow well with leaky inspection chamber

Widespread groundwater contamination however, has occurred in many rural areas utilizing on-site wells and septic tank systems. This is because of effluent which is discharged onto the subsurface by soak away and as this often percolates into the same aquifer tapped by wells for domestic water supply (Banda et al., 2014). Septic tanks have been found to fail or leak profusely, contribute to the contamination of groundwater andcausing environmental damage (Sincero et al., 2004). Approximate times for septic effluent to pass through unsaturated zone to groundwater range from a few hours to a few days, depending on the volume of effluent and the distance to ground water (Robertson et al., 1991; Robertson, 1994; Robertson and Cherry, 1995). The rate of migration also depends on the lithology, porosity and permeability of the underlying soil formation. Signs that wastewater from your septic system could be reaching water sources include: wastewater backing up into household drains; bright green, spongy grass on the drain field, even during dry weather; poolingwater or muddy soil around your septic system or in your basement and finally a strong odor around the septic tank and drain field. The study aims at investigating the extent to which the wrong well location and construction has affected its water quality.

II. MATERIAL AND METHOD

A. Description of Study Area

Ifite Awka is a rural community located in the Awka South Local Government Area of Awka, Anambra State, eastern Nigeria, and lies at geographical coordinates latitudes 06^o 06' N and 06^o 15' N and longitudes 07^o 05' E and 07^o 15' E within the humid tropical rainforest belt that is characterized by wet and dry climatic season.. The study area falls around the school environment of Nnamdi Azikiwe University Awka, Anambra State. The rainy period is usually between April and October and the average annual rainfall is between 1100-1400mm spreading over an average of 90-120 days annually. The relative humidity varies between 60 and 80 percent.

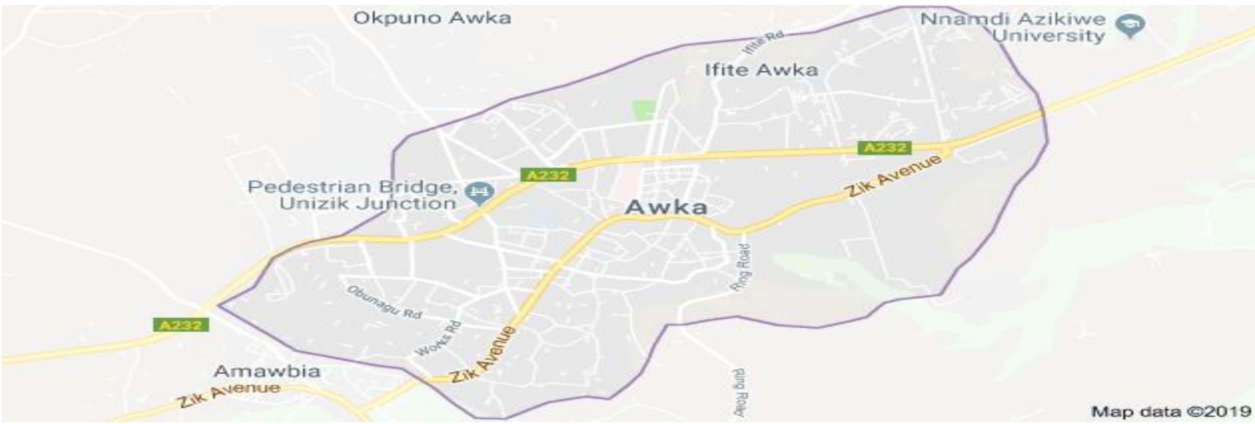

Figure 2 Map of Awka, Nigeria

B. Method

In this study, a shallow well used for this study is shown in Figure 1. Measurement of distance of shallow well to septic tank was taken with a tape. The well is situated in a compound that housed four flats located at Ifite Awka. The distance of its septic tank to the shallow well is 5.1meters adjacent to the well. The well is sited at a lower elevation within the yard. This shows that the distance is not even up to a minimum safe distance of 15meters published by many countries and agencies (USEPA, 2002). An inspection chamber was installed on a pavement that is higher and adjacent to the pavement of a shallow well at a point where an underground drainage pipe run changes direction. The well is the only source of water to the occupants of the building for which the well was installed to serve.

Water samples were collected from this well weekly for two months each in two different seasons (which are dry season and raining season). The study was done at the months of January and February for dry season and the months of August and September for raining season. Eight samples were collected for each season making it a total of Sixteen samples. Containers used for collecting the samples were thoroughly washed and sterilized using autoclave. A total of sixteen samples were collected and test analysis were carried out at Springboard Research Laboratory, Awka and the average values of the pH, total hardness, chloride, nitrate, total dissolve solid, turbidity, total coliform and E.coli were analyzed according to Standard Methods for the Examination of Water and Wastewater (APHA, 1998). However, pH was measured in situ using a portable pH meter.

C. Pollution index

Pollution index (PI) was used to determine the composite influence of individual parameter on the overall quality of the water sample (Amadi, 2011; Amadi et al, 2012). The rating has values starting from zero to five (0-5). The formula is given in equation 1.

$$PI = \sqrt{\frac{\left(\frac{Ci}{Si}\right)^2 max + \left(\frac{Ci}{Si}\right)^2 min}{2}} \qquad \text{-------equ.1}$$

Where
Pi = pollution index
Ci = Mean concentration
Si = Nigeria Standard for Drinking Water Quality

III. RESULT AND DISCUSSION

The result of the laboratory analysis of the shallow well water data is summarized in Table 1and and Table 2 for raining season and dry season respectively. The water quality classification based on pollution index is shown in Table 2.

D. Table 1 shows statistical summary of the well water sample during the dry season and raining season with Nigerian standard for drinking water quality

Parameter(mg/l)	Minimum	Maximum	Mean	NSDWQ (2007)
pH	5.4 (8.70)	6.78(9.50)	6.00(9.12)	6.5-8.5
Total Hardness	107(92)	210(480)	159.7(256.3)	150
Chloride	177(199)	260(305)	216.3(258)	250
Nitrate	13.71(20.9)	40.1(127)	25.39(36.88)	50
Total Dissolve Solid	442(457)	650(731)	508(596)	500
Turbidity	2.0(4.5)	3.8(5.8)	2.9(5.17)	5
E coli (Cfu/100ml)	2.08(3.61)	8.8(9.7).	6.4(6.7)	0
Total Coliform (Cfu/100ml)	5.05(12.0)	50.6(80.0)	10.3(12.4)	10

The values in parenthesis ( ) are result for well water sample during the raining season

E. Table 2 Water quality classification based on pollution index (Caerio et al., 2005; Amadi et al . , 2012)

Class	Pollution index [PI]	Status
Class 1	PI<1	No pollution
Class 2	PI:1-2	Slightly polluted
Class 3	PI:2-3	Moderately polluted
Class 4	PI:3-5	Strongly polluted
Class 5	PI:>5	Seriously polluted

F. Table 3: Calculated pollution index of shallow well in the study area for dry season

Parameters	PI value	Status
pH	0.72	No pollution
Total Hardness	1.11	slightly polluted
Chloride	0.89	No pollution
Nitrate	0.56	No pollution
Total Dissolve Solid	1.21	slightly polluted
Turbidity	0.61	No pollution
Total Coliform (Cfu/100ml)	3.60	Strongly polluted

G. Table 4: Calculated Pollution Index of Shallow Well in the Study Area for Raining Season

Parameters	PI value	Status
pH	1.06	slightly polluted
Total Hardness	2.30	Moderately polluted
Chloride	1.03	slightly polluted

Nitrate	1.82	slightly polluted
Total Dissolve Solid	1.11	slightly polluted
Turbidity	1.03	slightly polluted
Total Coliform (Cfu/100ml)	5.72	Seriously polluted

H. Table 5: Correlation matrix showing parameters of the water sample during dry season

	pH	*Total Hardness*	*chloride*	*nitrate*	*TDS*	*turbidity*	*Total coliform*
pH	1						
Total Hardness	0.017592	1					
chloride	-0.13132	0.45556	1				
nitrate	-0.6626	0.31691	0.429	1			
TDS	-0.12412	0.80683	0.54601	0.5559	1		
turbidity	-0.66461	0.3546	0.78712	0.5953	0.432268	1	
Total coliform(cfu/ml)	-0.05482	-0.0353	-0.2132	-0.313	-0.44199	-0.0924	1

I. Table 6: Correlation matrix showing parameters of the water sample during raining season

	pH	*Total Hardness*	*chloride*	*nitrate*	*TDS*	*turbidity*	*T.coliform*
pH	1						
Total Hardness	0.37743	1					
chloride	0.16648	0.4555591	1				
nitrate	-0.2205	-0.3301986	-0.5159142	1			
TDS	0.20919	0.269564	0.11443604	-0.2500321	1		
turbidity	-0.5553	-0.4476511	-0.0257308	0.2034835	-0.255773	1	
T.coliform	-0.0527	0.1227224	-0.2011538	0.534493	-0.566437	-0.26543	1

IV. DISCUSSION

From Table 1, It can be observed that the concentration of the physio-chemical parameters falls below the recommended limit for a safe drinking water by Nigeria Standard for Drinking Water Quality (NSDWQ (2007). All the parameter analyzed were subject to pollution index and the result (Table 3) for dry season, revealed that all the parameter falls within class1(indicating no pollution) except total hardness and Total coliform which fall within class 3 (indicating moderately polluted) and class 4 (indicating strongly polluted) respectively. The presence of E coli was detected in all the water sample which showed faecal contamination by human faeces in groundwater system. This result is in agreement withthe works of Bouderbala, (2019) whose finding suggest possible contamination of groundwater from septic tank due to short distance between well and septic tank.This may be attributed to leaking inspection chamber and septic system effluent seepage into the well.For Table 4, the result showed that the well water is highly polluted during raining season, based on all the parameters that was analyzed. This is attributed to polluting matter which might have seeped into the ground and contaminate the groundwater itself and then pumped into the well. Again, during heavy rainfall, pollutants might have flowed over the land surface and down around the top of the well and into the groundwater, which is then pumped into the well. From the Figure 1, it is evidently clear that the well is not properly covered neither was the wellhead sealed.

Correlation matrix (Table 4) showed that a strong positive correlation of 0.80683 exist between total dissolve solid and total hardness. This indicated that as total dissolve solid is increasing, total hardness is increasing. The potential source of the presence of total dissolve solid depend on the solubility and type of rocks formation of the aquifer of the study area. Water with high total dissolved solids usually is hard, because calcium and magnesium (the two elements that define hardness in water) are two of the major components of dissolved solids in groundwater. This shows that as TDS increases, total hardness increases. This indicate that both parameters (TDS and Total hardness) are strongly related and does not mean that one parameter causes change in the other. A strong correlation of 0.78712 also exists between chloride and turbidity. In Table 5 it was observed that there is either a low (≤ 0.3) and moderate (≥ 0.5) correlation existing between two parameters in water sample of raining season.

V. CONCLUSION

From the result of study, the well is moderately and highly polluted in the dry season and raining season respectively. The slightest contamination can be dangerous as young children can be very susceptible to infection with very slight contamination because they have not developed immunity to the bacteria in well. A pH values of less than 6.5 or greater than 8.5 may cause corrosion of the piping. The presence of E. coli in well water is usually the result of residential yard or seepage from septic systems.However, neither the groundwater flow direction was determined nor was individual depth of the shallow well, type of casing, the depth of water table measured in order to help in further confirming of the result of this study.

VI. RECOMMENDATION

Proper well location and construction are key to the safety of well water. The well should be located so rainwater flows away from it. Rainwater can pick up harmful bacteria and chemicals on the land’s surface. If this water pools near a well, it can seep into it and potentially cause health problems. The direction of groundwater flow help determines the most desirable location and the appropriate depth for the well. Tenants and landowners should check with water systems professional, septic tank service or local health department for standards in their area. Regular test is recommended for a property on which the septic system does not meet minimum separation standards, for bacteria at least twice a year.

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