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Impact of Proliferation of Borehole Development Projects on Groundwater Quality in Abia State, Nigeria

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ABSTRACT:
Proliferation of borehole development projects has impacted negatively on groundwater quality in Abia state due to its pressure on the aquifer, that result from continuous abstraction of ground water from the numerous locations of boreholes leading to salt water intrusion into groundwater and wrong site locations of water wells within areas of high pollution risk zones leading to infiltration of contaminants into groundwater wells through solute transport. These numerous borehole development projects was necessitated because of the failure of public water supply system that should have provided portable water to the inhabitants of the state who resorted to providing water for themselves through developments of these borehole projects within several individual households who drill water from very shallow aquifer systems that make the drilling projects cheaper financially. This research made use of Eno-scientific designed and manufactured water level meter (well sounder 2010 pro) to measure the depth of water table and thereafter, used Membrane filtration technique for laboratory analysis of microbial constituents of groundwater. Nitrate was determined by cadmium reduction method using HI83200 multi- parameter bench photometer at wavelength of 525nm while Ammonium was determined by Nessler method where HI83200 multi-parameter bench photometer was used at 420nm wavelength to analyze the twelve water samples collected within this research area. Arc GIS 10.2 was used for producing cartographical representations of spatially distributed geological formations, while Excel spread sheet was used in plotting the graphs. The secondary data for percentage distribution of households by major water sources show that boreholes had over 50% for the years 2007, 2008 and 2010 which was quite higher than other sources. The laboratory analysis of microbial constituents of groundwater shows that water was contaminated and was found with high values than the acceptable world health organization standard. Nitrate and Ammonia contaminations where also found in groundwater when results from laboratory analysis where compared with world health organization standard. These results necessitated this research to recommend rehabilitation of public water supply systems as well as well head protection zone development and regular treatment of contaminated wells and provision of large water storage facilities for rainwater harvesting so as to reduce the rate of proliferation of water drilling projects and reduce the rate of contamination of groundwater for the provision of best quality water supply in the state.
Keywords: Contamination, Proliferation, Drilling projects, Water quality, Aquifer, Borehole

INTRODUCTION

Groundwater exploitation is a Hydrogeological activity that needs expertise knowledge of latest developments in geo-environmental technological approaches in other to curb the problems of groundwater depletion, salt water intrusion, likewise chemical and microbial contamination of groundwater , exploited for domestic and industrial purpose Enyinna [1]. This research therefore becomes necessary to investigate the positive and negative effects of proliferation of water well development projects in Abia State, Nigeria, in other to recommend possible adaptation measures and solutions to the numerous environmental and hydrogeological problems arising from incessant citing of boreholes and hand dug wells in Nigeria.

Borehole drilling projects are continuously carried out in Abia state as far as housing development projects are carried out because; every house owner needs water supply to his house, 24 hours, 7 days in a week and 365 days in a year. Though, development of borehole projects are mainly carried out by private drillers for private ownership from the time public water supply systems in the state failed functioning Chima [2]. Adindu et al [3] noted that, Abia state has shallow water table especially within Abia south senatorial district which makes it less cost intensive to construct boreholes and hand dug wells within so many places as the need arises. The quantity and quality of groundwater reserve can be seriously affected by proliferation of drilled bore holes and hand dug wells by introduction of intensive pressure arising from heavy abstraction of water as a highly vulnerable resource Nkemdirim [4]. World health organization [5] specified that depletion of groundwater is usually because of over exploitation of groundwater resources with little or no intensive recharge system especially in areas of low rainfall that can cause a natural recharge process. World health organization et al [6] also stated that the formation of preferential flow from strong hydraulic gradients result from abstraction of groundwater which causes reduction in attenuation process but increases groundwater contaminants concentration.

Due to the financial benefits arising from water well development projects, numerous non-environmental and non- hydrogeological experts now go into borehole and hand dug well development thereby establishing site location of these water well projects close to waste dump sites, pit toilets, soak away pits, and septic tanks . This non expertise act, induces contaminant transport into groundwater sources because, these pollution sources are very close to the water wells. In that case, attenuation becomes difficult since microbial survival becomes certain within the short travel time that will be taken by the microorganisms to travel from a certain short distance from pollution site to groundwater source. Todds et al [7] in Madan et al [8] stated that "groundwater is emerging as formidable poverty alleviation tool which can be delivered to poor communities far more cheaply quickly and easily than canals" at such more people move into the business of groundwater exploitation thereby mounting much pressure that continuously deplete this valuable resource.

Howard [9] discussed issues regarding transmissibility of pathogen into groundwater, and stated that water is a major means of transportation of microbial contaminants into groundwater table. He also stated that, while some pathogens exist as aquatic organisms; some others are transmitted into water by disease caring agents through solute transport. Since groundwater is exposed to contamination mainly because of establishment of well heads at wrong locations a management adaptation strategy has to be applied to reduce the level of groundwater contamination through well head protection. Thus Conservation Ontario Natural Champions [10] stated that, wellhead is simply the physical structure of the well above ground which needs protection from pollution sources that may arise from land use activities around the well that have the potential to alter groundwater quality that flows into the well.

Proliferation of water wells has also mounted pressure on underground water through continuous water withdrawal that gives way to salt water intrusion. According to UNEP [11], the total withdrawal of water in Nigeria was separated in different sectors. It allocated 10.1% to industrial withdrawal, 21.1 percent to municipal withdrawal, and 68.8% to agricultural withdrawal, which means that there is pressure on water for different uses from all the sectors in the country. These sectorial pressures in the face of failed public water supply systems is seen to have increased the level of proliferation of boreholes and subsequent contamination of groundwater Aquifer and water wells. This over abstraction of underground water also causes salt water intrusion into the water table with its resultant increase in hypertensive patients as reported by the hospitals within the area. United Kingdom water forum [12] specified that the continuous pressure on the borehole causes a corresponding decrease in water level to such a point that a depressed cone is formed because, the water level has reduced thereby allowing influx of water into the borehole from different directions which is response to pumping. The influx of water could come from any source of surrounding water bodies including saline water. Proliferation of water wells is also made easy in the area due to the location of the water table within the geological area of sandy Benin formation of highly prolific aquifer systems that exposes the water tables between the ranges of 18 meters to 37 meters. Nwachukwu et al [13] also stated that hand driven shallow private and commercial wells are easily drilled due to the water table debt of 37 meters to 55 meters within the Coastal plain sand where Aba north west and Owerri west are found. Meanwhile, Aba is located in Abia State specifically within Abia south district where we still find some area like Isi-Obehie in Ukwa West, Azumini in Ukwa East Ala Ojii in Ugwunagbo Local Government areas with water table of between 8 meters to 20 meters range Enyinna [14]. Though there are variations within some areas in Abia central and Abia north senatorial districts in terms of water table depth. Within such areas, water table range between 37 meters and 60 meters. Most of the wells within these areas are unprotected hand dug wells which are located within the valleys that lie between hills. Figure 1 below shows the geological map of Abia state, with different geological formations. Abia south district falls within the Alluvium and Benin formations located within the coastal region with the shallow water table (8-20 meters) , Abia central district falls mostly within Bende Ameke group and Ezeaku group with two local government areas(Isiala-Ngwa north and Umuahia south) that are partly within the Benin formation (20 -35 meters) while Abia north district shears the geological formations of Nkporo shale, Nsuka formation, Lower coal measure and Asu river group (35-60 meters).

MATERIALS AND METHODS

This research used Eno scientific designed and manufactured water level meter (well sounder 2010 pro) during field investigation of water table measurement. The procedure involves removal of cover of the well to show the cap and on removing the well sounder from the casing, and to make sure that the cable linking the probe connector and well sounder was properly plugged and the well cap was also removed from the well head after that, the rod shaped part of the probe was put into the vacuum where the well cap was removed and the probe was sealed properly into the hole. The on button was pressed on the well sounder and the result of the depth of the water table was recorded. This was done for 6 wells, two wells each were selected from two local government areas in three districts. Figure 2 below shows the picture of a portable water table meter produced by Eno scientific [16].

Arc GIS 10.2 was used for producing cartographical representations of spatially distributed geological formations, while Excel spread sheet was used in plotting the graphs of water tables.

Abia state was delineated into 3, Abia south, Central and North. 12 water samples were collected from well heads in 12 local government areas, preserved in iced cooler on

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site, analyzed in Government Certified Laboratory.

MICROBIAL AND CHEMICAL ANALITICAL TECHNIQUE

Membrane filtration technique was used where 100ml of water sample were filtered under vacuum on the sterilized Nitrocellulose filter (0.45mm) using filtration rack. The filter paper was placed on a Nutrient agar plate, MacConkey agar, Eosin- Methylene blue agar plate, and potato dextrose agar plate. The Petri dish was inverted in an incubator at 37°C - 41.5 °C between 24-48hrs for bacterial colonies and at 25°C for Fungi colony for 120hrs.After incubation, growth of colonies were observed and counted .

Nitrate was determined by cadmium reduction method using HI83200 multi- parameter bench photometer at wavelength of 525nm.10 ml of sample was put into 2 separate sample cell bottles 1 was used as blank to zero the photometer.1 sachet of Nitrate powder pillow was added to second sample cell bottle inserted into cell compartment for 4minutes 30 seconds, the read was pressed and results displayed in mg/l.

Ammonium was determined by Nessler method. HI83200 multi-parameter bench photometer was used at 420nm wavelength.10ml of sample was poured into 2 separate cell bottles using 1 as blank to zero the photometer.4 drops of HI93715A-0 was added to the other cuvette and the solution was mixed. Cuvette was re-inserted into the instrument, for 3minutes 30seconds, read button was pressed at count down and results recorded.

RESULTS AND DISCUSSIONS

Figure 3 below shows the graph of water table and well depth, selected from three different senatorial districts in 6 local government areas in Abia state. Ukwa. W, represents Ukwa west local government area, Ukwa. E, represents Ukwa east local government area, WT, represents water table, WD represents well depth and m represents meters.

Ukwa west and Ukwa East are in located in Abia south district within the geological settings of Benin formation, Umuahia north and Ikwuano are located in Abia central, within geological formation of Bende Ameke group and Alluvium deposit respectively while Bende and Ohafia local government areas are located in Abia north senatorial district, within Ezeaku group and Nsuka formation, respectively. The location of the different local government areas in various geological settings determines the nature of the groundwater formation.Ukwa west and Ukwa east fall within geological formation of shallow water table. Umuahia and Ikwuano fall within geological settings of deeper water table while Bende and Ohafia fall within geological formations with water tables deeper than the previous local government areas.

The failure of public water supply system in Abia state is seen as a major reason for the proliferation of bore holes because the increasing population of the state demands a steady quality water supply to individual households piped to the different houses. Since people must make use of water and the public water supply system does not function effectively to serve the water needs of the population, individuals resorted to drilling private bore holes to satisfy themselves. This is encouraged by the hydrogeological formation of the area which has mostly; shallow water table that makes bore hole drilling cheaper and affordable for individual households. The level of proliferation is showcased on table 1 below which displays the percentage distribution of households by major sources of water for cooking and drinking in Abia State.

RESULTS FROM LABORATORY ANALYSIS OF GROUNDWATER SAMPLES

Figure 4 shows the results of laboratory analysis of groundwater that determined the level of microbial contamination resulting from proliferation of boreholes and hand dug wells. The meanings of abbreviations on the graph are as follows: (TFC) total fecal count, (TEC) total E coli count, (TVC) total vibrio count and (TSC) total salmonella count. They are all measured in cfu/100ml.

The graph below shows the results from laboratory analysis of water groundwater samples showing the level of microbial contamination in groundwater when compared with world health organization (WHO) standard. The abbreviations on the graph P1-P12 on the x axis are the different locations of boreholes where water samples were collected while the figures on y axis indicate the level of microbial contamination, measured in cfu/100ml.

The results on the graph show that first water sample collected from the first borehole, (P1) the water sample had high microbial constituents than WHO standard. TFC was higher, TEC was higher, TVC was low and TSC was higher than WHO standard.

The second water sample P2 shows that, TFC was higher, TEC was higher, TVC was low within WHO acceptable standard and TSC was higher than WHO standards. The third water sample (P3) shows that TFC was higher, TEC was higher, TVC was higher and TSC was higher than WHO standards. The fourth water sample (P4) shows that TFC was higher, TEC was higher, TVC was higher and TSC was higher than WHO acceptable standards. The fifth water sample P5 shows that, TFC was higher, TEC was higher, TVC was low and TSC was higher than WHO standards. The sixth water sample P6 shows that TSC was higher than WHO standard while TEC, TVC and TFC where low and are within the WHO acceptable standard. The seventh water sample P7 shows that, TFC was higher, TEC was higher, TVC was low within WHO acceptable standard and TSC was higher than WHO standards. The eight water sample (P8) shows that TFC was higher, TEC was higher, TVC was higher and TSC was higher than WHO acceptable standards. The ninth water sample P9 shows that, TFC was higher, TEC was higher, TVC was low and falls within WHO acceptable standard and TSC was higher than WHO standards. The tenth water sample (P10) shows that TFC was higher, TEC was higher, TVC was higher and TSC was higher than WHO acceptable standards. The eleventh water sample P11 shows that, TFC was higher, TEC was higher, TVC was low and falls within WHO acceptable standard and TSC was higher than WHO standards and, The twelfth water sample (P12) shows that TFC was higher, TEC was higher, TVC was higher and TSC was higher than WHO acceptable standards .

The graph below shows the laboratory analysis of borehole water samples, showing the groundwater constituents of Ammonia and Nitrate concentration in water when compared with WHO acceptable standard. The abbreviations on the graph are (AMM), (NIT) and WHO and they are Ammonia, Nitrate and world health organization respectively.

The WHO standard for Ammonia is zero while WHO standard for Nitrate is 40. Laboratory analysis of the first water sample P1 shows that, both Ammonia and Nitrate where above WHO acceptable standard. Laboratory analysis of the second water sample P2 shows that, both Ammonia and Nitrate where above WHO

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acceptable standard. Laboratory analysis of the third water sample P3 shows that, both Ammonia and Nitrate where above WHO acceptable standard showing that the water samples are contaminated with Ammonia and Nitrate. Laboratory analysis of the fourth water sample P4 shows that, Ammonia is below WHO acceptable standard which means that there was no Ammonia contamination while Nitrate is above WHO acceptable standard showing that there is nitrate contamination in the analyzed water sample. Laboratory analysis of the fifth water sample P5 shows that, Ammonia is below WHO acceptable standard which means that there was no Ammonia contamination while Nitrate is above WHO acceptable standard showing that there is nitrate contamination in the analyzed water sample. Laboratory analysis of the sixth water sample P6 shows that, both Ammonia and Nitrate where above WHO acceptable standard showing that the water samples are contaminated with Ammonia and Nitrate. Laboratory analysis of the seventh water sample P7 shows that, Ammonia is below WHO acceptable standard which means that there was no Ammonia contamination while Nitrate is above WHO acceptable standard showing that there is nitrate contamination in the analyzed water sample. Laboratory analysis of the sixth water sample P8 shows that, both Ammonia and Nitrate where above WHO acceptable standard showing that the water samples are contaminated with Ammonia and Nitrate. Laboratory analysis of the ninth water sample P9 shows that, Ammonia is below WHO acceptable standard which means that there was no Ammonia contamination while Nitrate is above WHO acceptable standard showing that there is nitrate contamination in the analyzed water sample. Laboratory analysis of the tenth water sample P10 shows that, Ammonia is below WHO acceptable standard which means that there was no Ammonia contamination while Nitrate is above WHO acceptable standard showing that there is nitrate contamination in the analyzed water sample. Laboratory analysis of the eleventh water sample P11 shows that, Ammonia is below WHO acceptable standard which means that there was no Ammonia contamination while Nitrate is above WHO acceptable standard showing that there is nitrate contamination in the analyzed water sample and the Laboratory analysis of the twelfth water sample P12 shows that, both Ammonia and Nitrate where above WHO acceptable standard showing that the water samples are contaminated with Ammonia and Nitrate.

Table 1: Percentage Distribution of Households by Major Sources of Water in Abia State

Year	Total house holds	Treated piped borne water	Untreated piped borne water	Bore hole/ Hand pump	Protected hand dug wells/ Springs	Unprotected Hand dug wells/ Spring	Rain Water	Streams/ Pond /River	Tankers /trucks/ Vendors	Other Sources
2007	983,486	0	1.4	53.4	0.1	0.2	0	43.4	1.3	0.1
2008	983,486	1.3	0	57.9	0.5	0.3	0.3	38.3	1.3	0
2010	983,486	2.4	2.4	52.6	1.7	0.2	19.3	17.0	3.5	0.6

Source: National Bureau of statistics in Nigeria [18]

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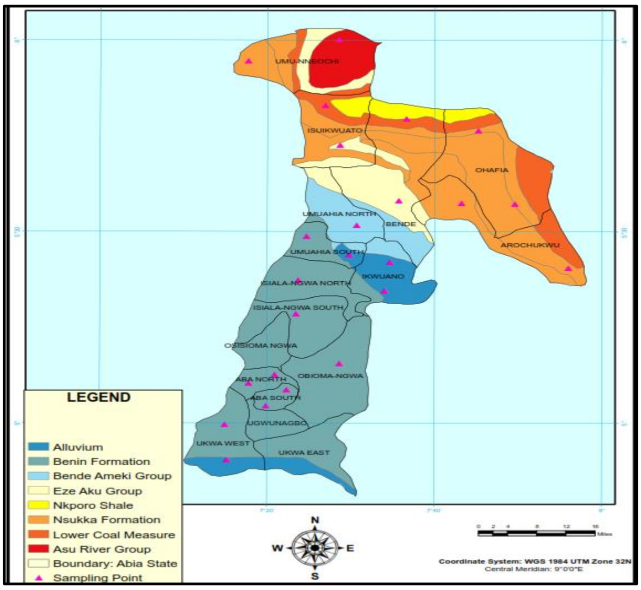

Figure 1: Geological Map of Abia state [15]


Figure 2: Portable well sounder probe (Eno- Scientific 2010) [16]

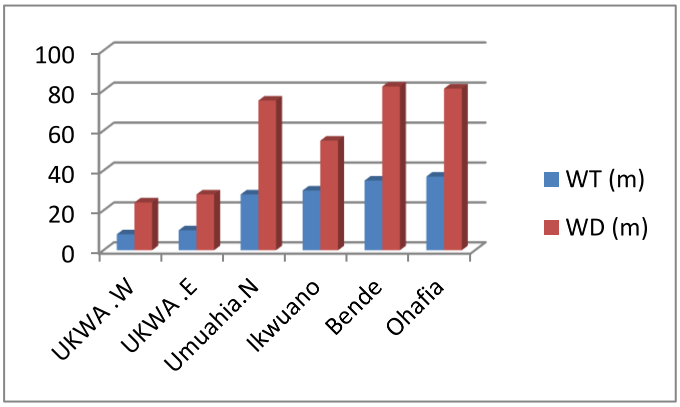

Figure 3: Water table and Well depth in Abia state [17]

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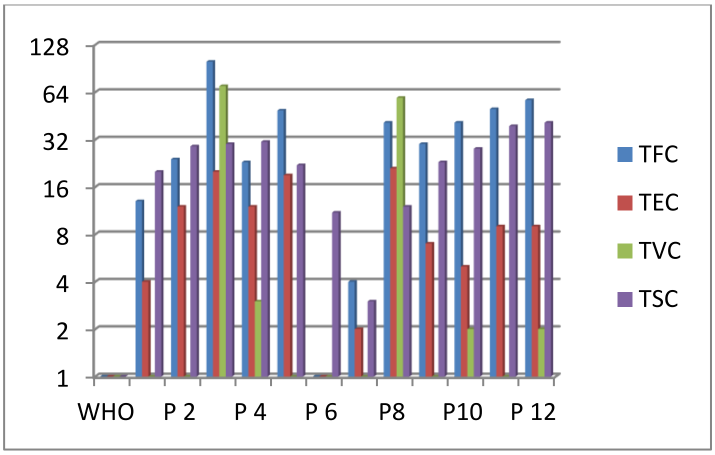

Figure 4: Results from Laboratory analysis of microbial constituents of water samples [19]

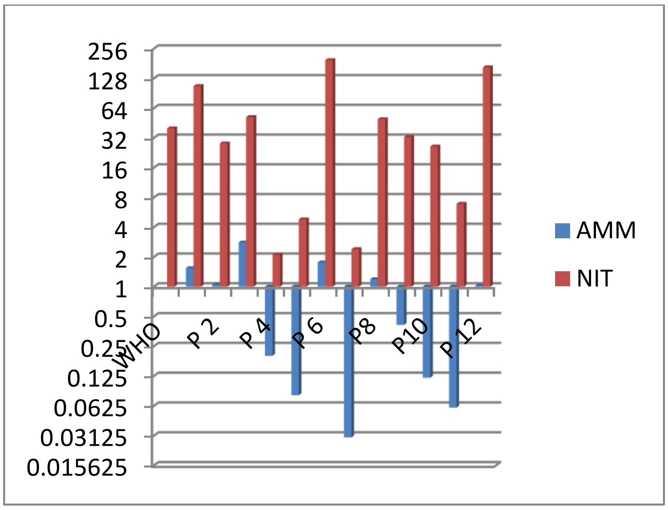

Figure 5: Results of laboratory analysis for water samples showing Ammonia (AMM) and Nitrate (NIT) constituents [20]

CONCLUSION

The extent of groundwater contamination is seen to have resulted from the fact that public water supply systems failed which made different households to employ the services of private water well drillers to drill boreholes and hand dug wells for them leading to proliferation of boreholes and hand dug wells. Most of these private water well drillers lack hydrogeological and environmental knowledge and expertise to determine the best location for these water wells. They establish most of the wells very close to different pollution sources leading to infiltration of contaminants into groundwater with its resultant water related diseases occurrences.

These impacts of proliferation of borehole drilling could be reduced through adaptation measures that could reduce the ongoing proliferation and the level of contamination of underground water sources. Thus the adaptation measures will include: encouraging rainwater harvesting since rainy season in this area covers between seven to eight months of the year. This will be done through provision of water storage facilities in the state by the state and provision of a functional water treatment facility for the treatment of harvested rainwater.

This will discourage proliferation of bore holes and hand dug wells in the state.

There is also need for collaboration between the government and other interested private organizations in resuscitation and sustainable management of public water supply systems that will supply water at an affordable price to the individual households all through every year. This public private partnership could focus on construction well head protection zones to protect the groundwater sources from microbial and chemical contaminations. The partnership could also consider the issue of mitering for homes with piped water supply for proper economic viability that will encourage sustainability of their services.

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