Groundwater Evaluation of Sedimentary Formation and Basement Complex

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Abstract: In the basement complex, the aquifers usually exist under water table conditions because they are unconfined while the sedimentary basins show greater complexity because water may be obtained from more than one horizon in a vertical profile. *This study examines the effect of waste and the environment on the quality of groundwater of the sedimentary formations and basement complex of part of Ogun State, Nigeria. Samples of water were taken from Water Corporation, borehole water, water sold in sachets and well waters from the geologic areas under study with Water Corporation sample serving as control experiment. In addition to this, the depths were measured to determine the depth of wells and ground water levels. Using grab method, representative samples were taken from the effluent from the industries, 3 wells at measured distances 288.20m, 468.30m and 1219.20m respectively from the point of discharge of the waste. The samples and effluent from the sedimentary formations and basement complex were, in line with APHA (1985), tested for physico-chemical and microbiological parameters and the results compared with available standards. The results revealed that the activities of the industries have tremendously affected the quality of groundwater in the basement complex area and, when the results from sedimentary formations were compared with acceptable standard, some were found to be suspects in terms of quality. In line with available and acceptable global practice, in order to prevent widespread of water related diseases, methods of reducing these parameters in the wells were recommended for the inhabitants.*

Keywords; *Groundwater, Analysis, Sedimentary, Formation, Basement, Complex*

Introduction

Everyone generate wastes from food preparation, polluted water from rainfall and used water from the household. In urban areas, gas fuel or electricity is used in cooking, wood are also used and this brings about the production of ashes which automatically has to be disposed. Waste can be classified into domestic waste, industrial waste, agricultural waste and urban waste (Hammer, 1977). Industrial waste can be solid, liquid or gas that may be deadly or harmful to people or the environments and tend to be persistence or non-degradable in nature. Waste from chemicals and flammable or radioactive substances includes industrial waste such as pesticides and fertilizer meal waste, and household hazardous waste such as toxic paints and solvents. The use, storage, transportation, and disposal of these substances cause serious environmental and health risk, even nervous system disorder and death. Large-scale release of industrial waste and hazardous materials may cause thousands of death and contaminate air, water and soil for many years (Eckenfelder, 1989). The waste from factories varies as much as their raw materials and products and as such there are often packaging, off cut, spoiled materials, unwanted by-products, oil refineries produce a greater deal of solid bituminous waste. In many factories there are residues from fuel used for power or the incineration of chemical. In the case of agricultural waste, normally, crop residues and manure are returned to the land, but in recent times, concentrations of activity have resulted in a concentration of waste that cannot be absorbed by the land, and as a result, goes into the groundwater by infiltration and percolation thereby contaminating the groundwater (Ola, 1983; Rahaman and Malamo, 1983; Hammer, 1977; Eckenfelder, 1989; Dwarf, 1992; Jones and Hockey, 1964; Todd, 1959).

Background Study

Human activities such as waste generation and disposal, agriculture, etc. on the sedimentary formation and basement complex pollute groundwater which make it unfit for consumption. There are a lot of human activities and industries located on the basement complex of Abeokuta Formation around Idi-Ori along Lagos-Abeokuta dual carriage-way, Abeokuta, Ogun State, Nigeria. These industries use raw materials in their daily operations which eventually results to solid and liquid waste generation. When these wastes are not properly treated or disposed, it finds its way into the body of the groundwater and pollutes it.

Methodology

From the sedimentary formation of Ilaro and Oja-Odan and basement complex of Abeokuta Formation, Ogun State, Nigeria, around the industrial area samples of water were taken from Water Corporation, borehole water, water sold in sachets and well waters from all the geologic formations under consideration with Water Corporation sample serving as control experiment. In addition to this, the depths were measured to determine the depth of wells and ground water levels. Using grab method, representative samples were taken from the effluent from the industries in the basement complex, 3 wells at measured distances 288.20m (well 1), 468.30m (well 2) and 1219.20m (well 3) respectively from the point of discharge of the waste as well as borehole water, water sold in sachets and well waters. The samples and effluent from the sedimentary formations and basement complex were, in line with APHA (1985), tested for physico-chemical and microbiological parameters and the results compared with available standards (APHA, 1985; Jones and Hockey, 1964; Ola, 1983; Rahaman and Malamo 1983; Todd, 1959).

Results and Discussion

Comprehensive Water Analysis from Sedimentary Formation

Ilaro districts and well depths comprises of Gbodidi (4.33m), Government Reservation Area, GRA (42.52m), Ikosi Quarters (36.61m), Ileba (15.5m), Library/Leslie/Kumuye (22.5m), Oma-Ola (39.67m), Musa (26.33m), Oke-Ela (2.56m), Oke-Ola (36.43m), Orita (34.88m), Sabo (0.49m), Udoji Road (2.88m) and Pahayi (32.33m) while the districts and depths of Oja-Odan comprises of Aranfe (13.075m), Oladitan (7.524m), Apetu (4.321m) and School Two (5.022m). From the results of the analysis of water from the sedimentary formation as well as well depths, taste and odour if present in water are usually due to decayed organic matter, microscopic organism and metallic part of corrosion or industrial wastes, none of which exists in all the water samples used for analysis. The free carbon dioxide present in well waters indicates that the water is acidic with pH ranging from 5.52 at 25 deg C to 5.93 at 25 deg C compared to water corporation and sachet water with pH ranging from 6.65 deg C to 8.52 deg C at 25 deg C which are almost alkaline in nature since carbon-dioxide reacts with water to produce carbonic acid. The presence of carbonate also indicates temporary hardness of water. The water corporation result showed no trace of carbon dioxide, also sachet water result is minimal due to treatment. Total solids and total dissolved solid in all the tested samples are within the permissible limit. Control and sachet water could have been filtered during treatment and Ilaro well water from GRA, Ikosi and Oke-Ola as well as Oja-Odan (Aranfe area) well water samples might have experienced a natural filtration by the soil layers. The conductivity values ranges from 109 μScm^{-1} to 396 μScm^{-1} with Oja-Odan well water having the highest value and this indicate the presence of ionisable ions in the samples even though none exceed the permissible level. Nitrite was not detected in all the samples tested because nitrite is mostly common in runoff from places where fertilizer is used or in industrial waste. Nitrate is commonly found in all underground water due to the activities of nitrifying bacteria in soil, nitrogenous fertilizers and in run-off from cultivated land and sewage effluent. Elements like lead, copper, iron, and cadmium are not detected in the sample tested because they are commonly found in industrial waste; water carried by copper pipe, underground formation and discharge from mines or industries where lead is used (Ola, 1983; Rahaman and Malamo, 1983; Hammer, 1977; Eckenfelder, 1989; Dwarf, 1992; Jones and Hockey, 1964; Todd, 1959). Phenophtalein was detected in control sample while in sachet water and Oke-Ola well water in Ilaro, it was nil because the water is acidic. For the total hardness, the result of Oja-Odan well water with 116mg/l exceeded the standard which indicates that the water is hard followed by Gbogidi well water with 80mg/l. Water Corporation and sachet water are within the permissible limit of Standard Organization of Nigeria and National Agency for Food, Drugs, Administration and Control standards. Excessive hardness in water precipitates soap, reduces cleansing action, cause scale in water distribution mains and hot water heaters and produces clogging in pipes. Calcium is most abundant in natural waters as indicated in the results, it precipitate soap. Sulphates are generally unobjectionable; therefore the quantity ranging from 7.6mg/l to 11.3mg/l in all the samples tested is very low compared to the acceptable standards of 100mg/l. Large quantity of sodium and magnesium sulphate causes bitter taste and diarrhea and calcium sulphate causes permanent hardness of water. Nitrate is very few in quantity in all the tested samples ranges from 0.01mg/l to 0.1mg/l. The chloride content in the tested samples ranges from 34.0mg/l to 62.0mg/l with Oja-Odan well water taking the lead but it is appreciably within the permissible standard. Chloride causes taste and its corrosion is very serious. Silica is present in the Water Corporation, Oja-Odan and Gbogidi well waters while no traces were detected in sachet water and Oke-Ola well waters even though no standard is set for it. It exists in most natural waters and no evidence that too much silica in water will cause any health problem. The counts of aerobic mesophilic organisms present in the Gbogidi and Oja-Odan tested well water samples is 214 CFU/ml and 138 CFU/ml respectively and is more than the permissible standard of 100CFU/ml given by acceptable standards. No traces of Coliform and E. Coli in all tested samples. Details of the results of comprehensive water analysis of sedimentary formation could be found in Olarewaju (2019) (Ola, 1983; Rahaman and Malamo, 1983; Hammer, 1977; Eckenfelder, 1989; Dwarf, 1992; Jones and Hockey, 1964; Todd, 1959; Olarewaju, 2019).

Comprehensive Water Analysis from Basement Complex

From the results of the analysis of water from the basement complex and well depths and distances from the point of discharge of wate, the presence of sulphate depicts that there is a decrease in the concentration of sulphate in the wells as the distance of wells from the point of discharge increases. The nearness of the saturated zone to the land surface and manner of fluctuation of the top of this zone has direct effects on the soil formation, the chemical and bacteriological quality of the groundwater body and these necessitate the need to measure the depth of wells. Sulphates are present in the discharge effluent in high quantity and its origin could be trace to soap industry which uses sulphuric acid in water. Sulphate are present in effluent discharged by industries and have contributed to presence of sulphate in well water. Sulphates are present in higher quantity in well at 288.20m nearest to the point of discharge of waste compared to other samples. The farther the well from the point of discharge of effluent, so is the concentration of sulphate in all samples conforming to acceptable standards. These sulphates include calcium sulphate, hydrogen sulphate, sodium and magnesium sulphate which when present in large quantity causes very bitter taste and diarrhea. Nitrates are present in effluent in high quantity while the concentration of nitrate decreases with increasing distance of wells from point of discharged effluent but nitrates also naturally occurs in soil. Nitrates are present in the discharged effluent in high quantities but are found in all samples in very minute quantity. It is obvious that the nitrate in the effluent has not in any way contributed to the presence of nitrates in the sample because the concentration of nitrates in all samples conforms to acceptable standards. Chlorides were found in high quantity in the effluent while the concentration of chloride decreases with increasing distance of wells from the point of discharge of effluent. Chloride are present in the highest quantity in well 1 at 288.20m which is the nearest to the industries. Concentration of chlorine deteriorates plumbing appliances, water heater and municipal water works equipments (Ola, 1983; Rahaman and Malamo, 1983; Hammer, 1977; Eckenfelder, 1989; Dwarf, 1992; Jones and Hockey, 1964; Todd, 1959). The result of methyl orange alkalinity is found in high quantities in the effluent while the farther the wells from the point of discharge of effluent, the higher the concentration of methyl orange alkalinity. The following compounds, caustic soda, limestone, all contain carbonate and the Standard Organization of Nigeria has no limit for methyl orange alkalinity in water. Total alkalinity of effluent were found to be high while it increases in well as the distance increases from the point of discharge. Caustic soda could result in total alkalinity which is caused by carbonate and bicarbonate of metal such as magnesium. Total alkalinity in well 2 and well 3 at 468.30m and 1219.20m respectively exceeds acceptable standards while total alkalinities were very high in effluent. Silica was found in high quantities in effluent while in the wells, it increases with increasing distance of wells from the point of discharge of effluent. Silica is found naturally in soil. The standard organization of Nigeria has no limit for amount of silica in water. There is no evidence that too much silica in water will cause any health problem. It causes hard scales in boiler feed water. Total solids were found in very high quantities in effluent due to discharge of solid waste, but decrease in well as the distances of well increases from the point of discharge. The reduction in well could be due to infiltration capacity of the soil. The total solid in the effluent has contributed to concentration of solids in all the samples, with the nearest well to the industries having the highest concentration of total solids. Total dissolved solids were found in very high quantity but reduce in well as the distance increases from the point of discharge. Total dissolved solid consist mainly of carbonate, bicarbonate, chloride, sulphate, phosphate, nitrite, calcium, sodium, and other. Total dissolved solid in natural water range from less than 10mg/l for rain to more than 100,000mg/l for brines but all samples are within the acceptable standards (Ola, 1983; Rahaman and Malamo, 1983; Hammer, 1977; Eckenfelder, 1989; Dwarf, 1992; Jones and Hockey, 1964; Todd, 1959).

The suspended particle increases in the well as the distance from the point of discharge increases. These particles enter the ground water through run-off containing silt, clay particles, decayed leaves, algae and fungi. Standard Organization of Nigeria has no limit for suspended particles but concentration of suspended particles was found in well 3 at 1219.20m which is very far from the part of discharge; this means there is no relationship between degree of concentration and distance. The effects of suspended particles are acidic, taste, change of colour, bacteria which result into contaminants and it also causes turbidity in raw water. The result of conductivity shows that the conductivity in the effluent is very high. The conductivity decreases with increasing distances of the well from point of discharge and is an indirect measure of the presence of the dissolved solid such as chloride, nitrate, sulphate, phosphate, sodium, magnesium, calcium, and iron and can be used as indicator of water pollution. Conductivity is a measure of how well water can conduct an electric current; it increases with increasing amount and mobility of ions. Though found within the acceptable standards, conductivity is useful as a general measure of total dissolved solid and stream water quality, pollution from irrigation, clearing land near a stream, fertilizer overuse or discharge of brine waste water can all cause water conductivity to increase, indicating higher level of dissolved solids and details of these could be found in Olarewaju (2019) (Ola, 1983; Rahaman and Malamo, 1983; Hammer, 1977; Eckenfelder, 1989; Dwarf, 1992; Jones and Hockey, 1964; Todd, 1959). PH of effluent is very high but increases with increasing distance from the point of discharge. There is no doubt that the pH of the effluent has contributed to the pH of the samples, due to chemical composition of effluent. All samples are within the acceptable standards. High pH water causes bitter taste; suppresses effectiveness of the disinfection of chlorine. Low pH water will corrode metal or other substances. Nitrites were found in high quantities, it decrease in well as the substance of well from the point of discharge increase. Nitrite is present in the soil by nitrogen fixing bacteria. Nitrites are found in the effluent discharged by the industries, but were found in small quantities in well 1 and well 2 at 288.20m and 468.30m respectively which are very close to the industries but not detected in other samples. There is a clear indication that nitrite is present in wells due to activities of the industries. Nitrite in well 1 and well 2 at 288.20m and 468.30m respectively exceeded the acceptable standards. Irons were found in high quantities in the effluent while there is an increase in the concentration of iron in the wells as the distance from the point of discharge of effluent increase. Iron occurs as a natural mineral from sediments or rock i.e. it is in rock composition. Irons were present in well 2 and well 3 at 288.20m and 468.30m respectively as well as borehole sample, all samples conform to acceptable standards. Iron imparts a bitter taste to water, a brownish colour to laundered clothing and plumbing fixture. The results of total hardness were present in low quantity in effluent. These raw materials of total hardness combine to form bicarbonate of metal which result into hardness. All well samples exceeded the acceptable standards while borehole and control samples conform to acceptable standards. Total hardness decrease lather formation of soaps and increase scale formation in hot water heater. Aerobic mesophilic organism were absent in the effluent because the composition of effluent is not a conducive environment for organism but aerobic mesophilic organism were present in all samples and the quantities are above the permissible level. Mesophilic organisms were present in all samples and are above permissible level. Odours are indicative of organic and non organic contaminant that originates from industrial waste and it causes water to be irritating. Lead and copper enter drinking water primarily through plumbing materials and exposure to lead and copper may cause health problems varying from stomach distress to brain damage. Copper causes intestinal and stomach distress, liver and kidney damage and anemia in high doses. It impact an adverse taste and significant staining to clothes. Lead affect red blood cell chemistry, delay normal physical and mental development in babies and young children and details of the results of comprehensive water analysis of basement complex could be found in Olarewaju (2019) (Ola, 1983; Rahaman and Malamo, 1983; Hammer, 1977; Eckenfelder, 1989; Dwarf, 1992; Jones and Hockey, 1964; Todd, 1959; Olarewaju, 2019). Details of these and many more could be found in Olarewaju (2020).

Conclusion

The samples from well waters of sedimentary formation are acidic with particles and high counts of aerobic mesophilic organisms. Elements like iron, lead, copper are not detected in all the water samples tested, because the study area is clay, limestone and sandstone that formed as a result of accumulation and compaction of layers of sediment and there are no industries like refinery, textile industry, etc. and due to zero count in E. coli and coliform, the water can be used for domestic purposes if adequately treated. From the results of the basement complex, aerobic mesophillic organism were present in all the samples from wells including samples from borehole and control except in effluent generated by the industries and the count limit exceeded the acceptable standards. Sulphate, chloride, total solid, total dissolved solid, nitrite and conductivity present in well waters decreases as the distance increases from the point of discharge of the effluent. The presence of iron in all the samples except sample from Water Corporation is an indication of the geologic formation of the industrial area. Finally, aeration, pH adjustment, filtration and disinfection are hereby suggested as treatment to improve the quality of the well water in these areas (Ola, 1983; Rahaman and Malamo, 1983; Hammer, 1977; Eckenfelder, 1989; Dwarf, 1992; Jones and Hockey, 1964; Todd, 1959; Olarewaju, 2019). Details of these and many more could be found in Olarewaju (2020).

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