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Groundwater Quality in Nigerian Urban Areas: A Review

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Groundwater Quality in Nigerian Urban Areas: A Review

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I. Introduction

In Nigeria, the rate of urbanization characterized by high population concentration ,increasing industrial and agricultural activities coupled with environmental pollution/degradation and indiscriminate disposal of all kinds of wastes are perceived to pose serious pollution threats with all its concomitant health hazards on groundwater quality especially in urban areas (Kehinde, 1998; Adelana et al, 2003., Adelana et al,2004; Adelana et al, 2005; Ajala,2005; Ocheri, 2006, Adelana et al, 2008; Eni et al,2011). This concern has attracted overwhelming attention of researchers in different parts of Nigeria urban areas. This borders on the fact that the public or municipal water supply is inaccessible to a large proportion of urban dwellers, and even where is available the supply is highly inadequate, unreliable and irregular. Consequently, there is high dependency on untreated groundwater abstracted through hand dug wells and borehole systems (Ocheri, 2006; Ocheri, 2010). According to Forster et al (1998) urbanization affects the quality and quantity of underlying sub-surface water by radically changing the pattern and rate of recharge, initiating new abstraction regimes and adversely affecting the quality. In this paper, attempt is made to bring together studies carried out on Nigeria urban groundwater quality with the view to ascertaining the current status, trend and possible protection and remedial practice. It is hoped that it will be of interest to researchers, water managers, policy makers and the genera public since water is used by all.

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II. Geology and Groundwater Pollution

Fundamental to the study of groundwater in any place is the geology of the environment. Geology is the main controlling factor in groundwater hydrology. The nature and the properties of the rock, aquifer specific yield and retention, the chemistry of water are governed by the geology of the environment (Brassington, 1988; MacDonald et al,2005).According to Sajad et al(1998) the quality of groundwater is a function of natural processes as well as anthropogenic activities, and that the type, extent and duration of anthropogenic activities on groundwater quality are controlled by the geochemical and physical processes and the hydrological condition present (Matthess,1976). Since groundwater is a product of geological formations, some studies examined groundwater quality in relation to influence of geology in an urban environment.

Du preez and Barber (1965) pioneered a hydrogeochemical investigation across geological formation of the northern part of Nigeria. They found that water from basement complex contains calcium or sodium bicarbonate, nitrate in high concentration of health implication. Water samples from cretaceous sediments of upper and lower Benue have elevated concentrations of iron especially in Binia-Yola sand and Yolde formation and also total dissolved solids, sulphate and salinity. Water samples from Jos plateau were found to be of good quality while that of Biu plateau has problem of hardness, alkalinity and salinity. In a similar study,Ezeigbo(1988)examined the influence of geology and hydrogeology on Nigeria environment and noted the following:

(i) high iron concentration was characteristic of groundwater in significant proportions practically in all states of Nigeria.
(ii) excessive concentration of manganese occur in significant proportions in parts of Rivers, Anambra and Imo States
(iii) low pH or acidic water was noted in calcareous rocks of Mamu, Nsukka, Ogwuasi-Asaba and Benin formations.
(iv) mining and processing of metallic ore and coal were noted to have affected both the surface and

groundwater sources with high iron, aluminum and sulphate in Enugu coal mine and lead-zinc mining area of the Benue Trough

(v) water hardness linked with limestone or calcareous rock formation as noted in Asu-group, Odukpani, Ezeaku shale, Awgu-Ndeabo group and Ewekero and Kalamina formation

(vi) salt intrusion in coastal areas as well as inland evaporates deposit in Uburu and Okposi in Imo State.

A comprehensive review of the status of groundwater chemistry of Nigeria by Edet etal (2011) covering the four major groundwater sedimentary basins of Benin, Benue, Niger Delta and Sokoto and crystalline basement complexes reveal the following: In general, on the average, total dissolved solids for groundwater for different basins was less than 250mg/L compared to saline groundwater as high as 15700mg/L. The high salinity was attributed to salts and seawater intrusion. Nitrate concentration on the average was noted to be high especially in Sokoto basin indicating anthropogenic pollution. Results of multivariate analysis and cross plot indicated that the major geologic controls on groundwater chemistry are chloride, dissolution, weathering (silicate and carbonate) and ionic exchange. The distribution of ions in groundwater of sedimentary and basement complex areas (excluding the saline water) indicate comparable concentrations with EC, Na, K, Mg and Cl higher in sedimentary areas relative to the basement complex. No geographical bias to the distribution was observed except on local basis and water tends to reflect the lithology. The distribution of ions in the sedimentary areas is as follows: Na>Ca>K>Mg/L and HCO_3>Cl>SO_4 and for basement is Ca>Na>Mg>K and HCO_3>SO_4>Cl. With respect to agriculture and irrigation purposes, beside saline groundwater from Benue basin and coastal aquifer, the groundwater are considered to be excellent.

The local geology of noticeable stratigraphic variation influences natural attenuation of contaminants, their pattern of transfer and subsequent breakthrough into groundwater. The existing hydrogeological setting of Lagos metropolis favours adsorption and retention of contaminants in the pore spaces, thereby making the pattern of leacheate dispersion very irregular and difficult to predict. As much as some of the contaminants are found in groundwater at concentrations higher than the background groundwater chemistry of aquifer in Lagos, there is therefore the tendency to suspect that landfill as one of the sources of groundwater contamination in Lagos (Longe et al, 1987). Adebo and Adetoyinbo (2009) assessed the groundwater quality in an unconsolidated coastal aquifer of Lagos, noted that of the parameters analysed, chloride concentration exceeded WHO guide limit for drinking water. This is traced to saltwater intrusion. Water type delineated include iron-calcium-magnesium-sulphate (Fe-Ca-Mg-SO_4), iron-chloride-bicarbonate (Fe-Cl-HCO_3), magnesium-chloride type (Mg-Cl). They concluded that the peculiar geologic and hydrogeologic condition that prevail in Delta area of Nigeria is what obtains here. Groundwater contamination and their flow characteristics in Ibadan was studied by Ajibade et al (2010). Major ions identified in order of abundance are Na> Ca> K> Mg> Al> P> Fe, trace elements So> Mn> Zn> Ni> C0> pb> Cu> Cr> Sb, anions HCO_3> Cl> NO_3> SO_4> br> PO_4> Fe. The calculated anthropogenic factor for the element shows lead, chromium, and strontium pose very high contamination factors. Water in the area is of two types: earth-alkaline water and earth alkaline with alkali compound.

Hydrochemical faecis of Delta Plain of Warri was delineated against the backdrop of the factor controlling groundwater quality of the area. Water samples were analysed for pH, TDS, K, Na, Mg, Cl, HCO_3 and SO_4 and the result subjected to R-mode factor analysis. Three factors were extracted by Olobaniyi and Owoyemi (2006).Factor 1 include K, Na, Cl and EC reflects the signature of saline water intrusion resulting from seepages into the aquifer of water from tide influenced River Warri. Factor II has high loading on Mg, Ca, HCO_3 and pH represent the processes of natural recharge and water and soil rock interaction. Factor III include SO_4 related to dissolution of sulphides from interstratified peat within the geological formation, heavy vehicular activity and the petroleum refining process in the town. Also in Warri town, Akunobi and Chibuzor (2012) assessed the quality of groundwater and found water to be acidic to slightly acidic. Heavy metal such as Cu, Cr,Zn,Cd and Pb were found in traces. Water type delineated are Ca-Mg-HCO_3, Na-HCO3;Na-Cl.The predominance of alkali and alkali earth metallic ion and chloride are a major attribute of seawater intrusion, while heavy metal reflect the increasing impact of anthropogenic activities. Also within the Niger Delta area, Nwankwoala and Udom (2011) found to the eastern part, groundwater to be acidic, high chloride concentration linked to saltwater intrusion, and high iron content in the wells. Groundwater is classified into three types: type 1 Ca-Mg-Cl-SO_4 and Na-K-Cl-SO_4, type II water influenced by No3 area mainly made up of mainly of mixture of earth alkaline and alkaline metal predominantly Cl-So4.Chloride is the dominant anion followed by sulphate. Amadi et al (1989) earlier found some parts groundwater to be enriched with Na, Ca, Cl, HCO_3 and So4, salinity, TDS and total hardness. General increase in Cl and decrease in HCO_3 content towards the coast is associated with saltwater intrusion. Five groundwater types were identified: (i) sodium-calcium-bicarbonate (ii) Na-Ca-Mg-HCO_3.In Yenegoa town within the region, Amangabara and Ejienna(2012) noted from the analyses of the physico-chemical concentrations in wells to be a reflection of the hydrochemical faecis of groundwater of the area. The ionic trend of the area is Ca>HCO_3>Na>K>Mg>Cl>SO_4.Na >K>Cl. The elevated occurrence of Ca>HCO_3>Mg ions in the groundwater beyond the WHO prescribed limit reflect the process of natural rainwater recharge and water-soil/rock interaction. Nwankwoala and Udom(2011) assessed the hydrogeochemistry of groundwater using 18 representative wells in Port Harcourt town. Physico-chemical parameters analysed include pH, EC, Ca, Na, K, Cl, HCO_3 and So_4.Ionic order identified is Ca> Mg>K>=HCO_3>Cl>SO4>NO_3. Ca-Mg-HCO_3 and Ca-Mg-SO_4 were found to be the dominant hydrochemical faecis. Ion exchange process of carbon and silicate weathering is responsible for groundwater chemistry of the area. Hydrochemical indices Mg/Ca, Cl/HCO_3 and cation exchange values generally indicate low salt inland with minimal marine influence. Okoye et al (2010) investigated physico-chemical quality of groundwater of Calabar and its environs, noted water to be acidic, trace elements such as iron, magnesium, aluminium and nickel to be less in concentration in the wells. The ionic relative abundance are Ca>Na>L>Mg>and Cl>So_4> HCO_3 .Groundwater type is Ca-Mg-Cl-So_4 and Ca-Mg-Na-Cl.In Aba town,Alichi et al(2010) noted groundwater to be very acidic, high total dissolved solids were recorded around dumpsites and high sulphate concentration around NNPC depot. Ionic order of abundance for cations are Na>Ca>Mg and anions No_3>Cl>SO_4.Five water samples were identified, Na-Cl-NO_3; Na-Ca-Cl-SO_4; Na-Cl;Na-Ca-NO_3 and Na-Ca-SO_4-No_3-Cl.Departure of the concentration levels of the parameters from the background suggest impact of urbanization.

Groundwater quality from basement complex of Abeokuta and Kano towns in the southwest and northcentral Nigeria were assessed by Ufoegbune et al (2009) and Adamu et al (2013) respectively. Results show that zinc, iron and lead had elevated concentrations above WHO prescribed limit in Abeokuta, while pH, conductivity, alkalinity, total dissolved solids were found to be lower in quartzite area than those of granite, schist and gneiss areas of Kano town. The pattern of pH, Co_2 portray similar trend in the four rock types. In a hydrochemical and isotopic characteristics of groundwater in Central Abuja,Dan-Hassan et al(2010) found water to acidic in some areas,low total dissolved solids and Disolved Oxygen.The predominant hydrochemical faecis delineated are Ca-HCO_3 and Na-HCO_3.Chemical mixture and ionic exchange are probably responsible for chemical evolution of groundwater from Ca-HCO_3 to Na-HCO_3 type.In a hydrochemical assessment of groundwater in Dadin-Kowa area of Bauchi, Anudu et al(2010) identify groundwater to be slightly acidic to slightly alkaline, hard to very hard, and concentration of ions range are Ca, Mg,Na,K,Fe, HCO_3,SO_4 ,Cl. Concentrations of Fe, Cu, and Pb were above the prescribed limit for drinking water. Groundwater type delineated are Mg-Ca (Na)-HCO3; Ca-Mg-(Na) HCO_3; Mg-Ca(Na)-HCO_3-(So_4);Mg-Ca-HCO_3:Mg-Ca HCO_3(SO_4) and Ca-Mg-HCO_3-(SO_4). Water is alkaline.

III. Urbanization and Groundwater Pollution

African cities have a long history of water supply from surface and groundwater sources. However, due to deteriorating quality and quantity of surface water through increased urbanization and industrialization and high cost of developing new dams urban groundwater is viewed as a better option (Adelana et al, 2008).This advantage notwithstanding, urbanization has important overall implications for freshwater use and waste management, and specifically for the development, protection and management of sub-surface water in an urban environment (Eni et al, 2011).

In a comprehensive study by Adelana et al(2003,2004,2005) of groundwater quality of the southeastern parts of Lagos from 1999-2001on the impact of urbanization, found that of the water samples analysed, concentrations of sulphate, nitrate and chloride at objectionable proportion were noted in all the wells. Nitrate particularly was noted to be very high and is linked with anthropogenic activities. Groundwater in Lagos is particularly vulnerable to contamination due to shallow depth and the unconsolidated permeable sand and gravel aquifer. In a similar study, Eni et al (2011) assessed the impact of urbanization on the sub-surface water of Calabar town noted water to be acidic, nitrate and faecal coliform to have very high concentration in the wells. Results of multiple regression show faecal coliform,pH, and chlorine have positive relationship with urbanization. High faecal coliform is often associated with the sanitary condition of the environment of the wells. Amadi et al (2010) examined the effect of urbanization on groundwater quality of Makurdi metropolis. Results of analyses show water samples collected within the vicinity of dumpsite have low pH, higher concentration of iron, manganese, calcium and total dissolved solids and total coliform when compared to those far away from the dumpsite suggesting leachate influence. Presence of coliform is traced to sanitary condition of the well. Groundwater type is Ca-SO_4. In a related study, Tse and Adamu (2012) in the chemical and bacteriological analyses of hand dug wells in Makurdi town noted water to be slightly acidic, moderately hard, low total dissolved solids. Heavy metal such as iron, zinc, copper, lead and cadmium occur in traces, while high concentration of coliform is noted in all the wells.

IV. Groundwater Quality Status Studies

Of primary concern is the quality of groundwater exploited for drinking as well as other domestic uses. This is because consumption of water that is polluted has serious health implication as such World Health Organization has to set safe standards for drinking water. This concern has attracted overwhelming studies on the quality status of groundwater abstracted from shallow wells (hand dug wells) and deep wells (boreholes) for human consumption in urban areas of Nigeria.

In a baseline study on the inorganic and microbial contaminants of health importance in water from boreholes and open wells in Benin City, Erah et al(2002)found that all of them were contaminated with abnormal levels of lead, chromium, zinc and faecal coliform. They concluded that consumption of water from these wells will have serious implications. In related studies, Alexander(2008) Efe et al(2008)Al-Hassan and Ujo(2011) found groundwater to be slightly acidic, and calcium, magnesium, chloride and sodium concentrations were within WHO guide limit in Mubi town; hand dug wells located close to dumpsites in Onitsha have higher levels of turbidity, total suspended solids, calcium bicarbonate, electrical conductivity, salinity, acidity, lead. iron and bacteria loads; and for Masaka, water from all the wells analysed were polluted with chemical and bacteria, turbidity, dissolved oxygen, nitrates, chromium, total bacteria count, and concluded that water was not safe for drinking. Jatau et al(2006) in a preliminary investigation of the quality of surface and groundwater in parts of Kaduna Metropolis, noted groundwater to be slightly acidic, high iron , nitrate, faecal coliform concentrations. This is traced to leachates from wastes and dumpsites. Earlier, Egbulum (2003) used faecal coliform and faecal streptococcus indicator to assess the microbial quality of groundwater from hand dug wells in Mando and Kawo area of Kaduna,found that the wells were all contaminated, and that bacterial loadings increases from dry season to rainy season between 1998-2002.

In Gwagwalada area of Abuja Metropolitan City,Ishaya and Abaje(2009) found that groundwater from the boreholes analysed has turbidity, total dissolved solids,magnesium, total hardness concentrations above the WHO prescribed limit for drinking water in some of the wells. Nitrate was however within WHO guide limit for drinking water. Studies carried out by Yerima et al (2008) Danmo et al(2013) in Bama and Konduga towns in Bornu State in sudano-sahelian ecological zone, noted that nitrate, manganese, faecal coliform concentrations in both hand dug wells and boreholes were above the WHO permissible limit for drinking water. Idris-Nda et al (2011) appraised the chemical quality of groundwater quality of Minna metropolis and found heavy metals with high concentrations are magnesium, copper, arsenic and lead. Cation with highest concentration are manganese, sodium and dominant anions HCO_3,CO_2 and NO_3.The groundwater was generally found to be of good quality. In Jemeta area of Yola town, Ishaku and Ezeigbo (2010) analysed the quality of groundwater and found concentrations of chloride, nitrate, total dissolved solids and coliform to far exceed the WHO allowable limit for drinking water and were higher in the wet season. This is traced to anthropogenic activities as household wastes, waste-water find their way into water sources. Relationship show positive correlation for chloride,total dissolved solids, nitrate, sulphate, nitrate and total dissolved solids and sulphate for dry season, while nitrate and sulphate, total dissolved solids and sulphate, chloride and sulphate and chloride and nitrate.

In Ibadan Metropolis, Ayantobo et al(2012) assessed the quality of water from hand dug wells and noted nitrate, faecal coliform and total coliform at objectionable levels and are pronounced in wells located close to domestic wastes, abattoir, pit latrine and stagnant water and drainage. According to Omotoyinbo (2007) the pollution of groundwater by organic wastes in Ado-Ekiti is attributed to location of wells in terms of distance to toilet and refuse dumpes. Atarhe and Egbuna (2013) assessed the quality of water from hand dug well in Akure town noted groundwater to be acidic, with electrical conductivity to exceed WHO prescribed limit for drinking water. Hydrochemical facies delineated are calcium-sodium and bicarbonate-chloride-sulphate water types. Geology of the area is concluded to influence the quality of groundwater of the area.

Onwuka et al (2004) assessed the potability of shallow groundwater using parameters of waste derivable chemical such as nitrate, chloride, sulphate and indicator micro-organism of faecal coliform. Result show 22% of the wells have nitrate above WHO limit, and 8 out of 10 show evidence of faecal coliform derived from sewage contamination. In related a study, Omono et al(2013) used principal component analysis(PCA) to identify factors controlling groundwater in Achara, Abakpa and Emene residential areas of Enugu town.PCA was able to extract 77.7%,88.1% and 83.13% of the explained variables for the residential areas. PC 1 reflect weathering of the host rock minerals and constitutes the dominant controlling process of the areas. PC II and PC III of Achara and Abakpa is traced to both weathering/leaching of feldpatic minerals of host rocks giving rise to alkaline in groundwater and anthropogenic activities. Discriminant analysis of the groundwater quality of the area reveal total dissolved solids, sodium, manganese and chloride as dominant elements. Groundwater in the area is controlled both by geologic and anthropogenic activities.

Aiyegbusi et al (2010) analysed the quality of groundwater from shallow wells in Ilesa town in Osun State. They noted groundwater to be dominantly Ca-Mg(alkaline) and classified the water into Ca-Mg-Cl- SO_4 type; Ca-Mg-Na-K-HCO_3; Ca-Mg-Na-K-Cl-SO_4-HCO_3; Na-K-HCO_3.Heavy metals such as copper, lead, iron, chromium, arsenic, nickel in both surface and groundwater exceeded the WHO guide limit for drinking water. The presence of coliform in most of the water samples is linked to sanitary condition of the wells. In Ede town, Adediji and Ajibade (2005) assessed the quality of water from hand dug wells and found concentration of potassium to most abundant. All cations such as calcium, manganese, sodium, potassium were within WHO limit for drinking water. Jegede and Alade (2010) in their assessment of water quality from hand dug wells in Ijebu-Ijesa of the parameters analysed found lead, iron and cadmium levels to exceed WHO prescribed limit.

Ocheri and Odoma (2013) in a baseline study analysed the quality of water from boreholes in Lokoja town and noted concentrations of total coliform and lead to be above the Nigerian drinking water standards. Correlation was noted between coliform and nitrate, total dissolved solids and calcium, calcium and lead and geology. Ocheri and Ode(2012) assessed the quality of water from hand dug well in Oju town, Benue State, found the concentrations of iron, nitrate, and coliform above the WHO prescribed limit for drinking water. They attributed this to the shallow depth of the wells, distance to latrine/soakaway, improper well construction as well as landuse.

V. Groundwater Pollution from Landfill, Dumpsite and Abattoir Wastes

Proper management and protection of urban groundwater quality has been a major problem in Nigerian cities .Waste dumpsites are not properly designed nor constructed as landfill sites. Consequently, wastes dumped at dumpsites over the years are expected to have biodegenerated and generate leachates which could become point source of pollution into soil and groundwater (Bayode et al, 2012). The rate and characteristics of leachate production depends on a number of factors such as solid waste composition, particle size, degree of compaction, hydrology of the sites, age of the landfill, mixture and temperature of the condition and availability of oxygen (Ogundiran and Afolabi, 2008).

Ikem et al (2002) evaluated groundwater quality characteristics near two waste sites in Ibadan and Lagos found the concentrations of nitrate, ammonia, chemical Oxygen Demand, aluminium, cadmium, chromium iron lead nickel and total coliform to exceed WHO prescribed limit for drinking. The elevated concentration of these elements in groundwater is traced to leachates from the dumpsites. Longe and Enekwechi (2007) investigated potential impact and influence of local hydrogeology on natural attenuation of leachate at municipal landfill and groundwater of Lagos City and noted elevated nitrate, chloride, sulphate in groundwater and heavy metal chromium, calcium were detected at measurable level in groundwater down the gradient of the landfill location without any particular attenuation pattern of the well studied. Babatunde et al(2009) and Odukoya and Abimbola (2010) assessed the impact of leachate from dumpsites on groundwater quality in Isolo, Ojota and FESTAC areas of Lagos Metropolis and found elevated concentrations of iron, magnesium, nitrate, phosphate, sulphate and coliform above the prescribed limit for drinking water. They noted the concentrations of these elements were higher in water samples collected close to dumpsite than those far away thus suggesting the influence of leachate generated from dumpsites. In Ilupeju and Agbara industrial area Odukoya et al (2010) effluents discharged were noted to pollute the groundwater sources of the area. High concentrations of elements above WHO allowable limit in drinking water were observed in cadmium, antimony, barium, tellurium, tungsten, copper, lead and nickel linked to industrial effluent.

In Ibadan, Adeyemo and Temowo(2010) in a hydrogeological investigation of waste dumps noted the concentration levels of electrical conductivity, total dissolved solids, sodium, potassium, magnesium, nitrate and chloride were higher in water samples collected near the dumpsite than those far away. This is traced to leachate from dumpsite. Oladunjoye et al(2011) used geoelectrical imaging to measure the impact of waste dump of groundwater quality of Ibadan and concluded that high concentration of leachate towards lower elevation means the adjoining stream is prone to pollution from leachate from dumpsite. The environmental implication of municipal solid waste dumpsite leachate on contiguous hand dug wells in Ogbomosho was investigated by Ojoawo and Seriboh (2007). High concentration levels of turbidity, hardness, alkalinity, pH, calcium, nitrate, magnesium, zinc, phosphate and coliform were noted in the well close to dumpsite and evidence of leachate contamination.

Bayode et al (2012) assessed the impact of some waste dumpsite on the groundwater quality in some parts of Akure metropolis and of the parameters analysed, pH, electrical conductivity, total dissolved solids, calcium, and nitrate concentrated exceeded WHO prescribed limit for drinking water. This especially true of water samples collected within the vicinity of the dumpsite implying leachates may have contributed to the concentration level. According to Bayode(2010) pollution of groundwater from dumpsites in the basement complex of Southwestern Nigeria have been documented by Olayinka and Olayiwola(2001) Tijani et al(2002) Abimbola et al(2002) Abimbola et al(2005) Ayolabi and Daniel(2005) Obase et al(2009).

Omofonwman and Esigbe (2009) and Imoisi et al(2012) examined the impact of municipal wastes on the quality of groundwater in Benin City and found concentration levels of physico-chemical and bacterio-logical loading higher in wells close to dumpsite than those far away. Studies carried by Adeyemo et al (2002) Chukwu(2008) in Ibadan and Minna metropolis confirmed the pollution of hand dug wells from abattoir wastes. This is evident in high faecal coliform and nitrate concentrations in the wells located close to abattoir. In a related study, Ahmed (2003) investigated the effect of sanitation on groundwater in Kaduna, noted high peak values of sanitation pollution indicators such as coliform and nitrate. Hand dug wells located close to pit latrine and soakaway have higher concentration of these pollution bacteria.

VI. Groundwater Pollution from Heavy Metals, Nitrate, Iron

a) *Heavy Metals*

Heavy metals are individual metals and metal compounds that can impact human health. Common heavy metals of toxic effects are arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. They are naturally occurring substances which are often present in the environment at low level but augmented by anthropogenic activities. Generally, humans are exposed to these metals by ingestation (drinking and eating)or inhalation(breathing)(Martin and Griswold,2009).These metals may come from natural sources, leached from rocks and soils according to their geochemical mobility or come from anthropogenic sources, as a result of human land occupation and industrial operation. The increase in industrial activities has intensified environmental pollution problems and the deterioration of several aquatic ecosystems with the accumulation of metals in biota and flora. These trace metals are dangerous because they tend to bio-accumulate resulting in heavy metal poisioning(Abolude et al,2009).Because of the harmful effect of heavy metal in drinking water researches have been carried in these areas.

Oyeku and Eludoyin (2010) assessed heavy metal pollution of groundwater resources in Ojota area of Lagos metropolis, noted that hand dug wells and boreholes near Olusosun landfill were contaminated with heavy metals. The uncontrolled disposal of lead and batteries, spent petroleum products probably caused the relatively high level of lead, copper and iron in groundwater. The spatial and seasonal variation in the concentration level suggest point sources pollution. In a related study, Yaya and Ahmed(2010) found high concentration of heavy metals in water sources of Abuja FCT, Nigeria .Arsenic, lead, iron and zinc concentrations were particularly noted to be high in both surface and groundwater sources. At Ibadan metropolis, Laniyan et al (2010) in a geochemical investigation note quartzite rocks to have the highest arsenic concentration. They concluded that water sources in Ibadan are prone to arsenic contamination from both leaching of weathered bedrock and indiscriminate discharge of wastes and industrial effluent. Trace metals in surface and sub-surface area of Kaduna south industrial area was examined by Jatau et al (2008). Of the parameters studied, vanadium, chromium, iron, cobalt, nickel, gallium, arsenic, selenium, lead, stronium, zirconium, and Molybdenum accounting for 73.68% of the well have concentrations above the WHO guide limit for drinking water. Nwankwoala et al(2011) investigated heavy metal pollution of groundwater of Yenegoa town, and found the concentrations of iron, manganese, nickel, chromium, lead, arsenic, cadmium, mercury and copper to be above the WHO allowable limit for drinking water. They attributed this to industrial discharges and subsurface injection of chemicals being an oil producing area. Mile et al (2013) assessed heavy metal pollution in groundwater sources of Makurdi and sub-urban, noted high concentrations of chromium, cadmium, iron and copper above the WHO prescribed limit for drinking water. They attributed this to soil mineralogy, use of chemical fertilizers and agro-chemicals and other landuses. Of the heavy metal studied, lead because of its abundance due to industrial activity and its toxicity have been suspected in water sources.

Sridhar et al (1998) pioneered a study on lead contamination levels in indoor and outdoor environment of the populous city of Lagos and Ibadan. Lead pollution level in surface and groundwater beside soils, dust and foods were investigated. The results of analyses of lead level in various water sources indicate that majority of the waters showed lead level above the WHO prescribed limit. Water from low density areas in Ibadan recorded relatively higher lead levels. However, the groundwater from high areas in both cities showed significantly higher lead levels.

Musa et al (2004) determined lead level in wells and boreholes in Zaria City and found that 91% of the wells sampled had lead concentrations above the WHO permissible limit for drinking water. Higher lead level was noted in well near motor mechanic and industrial areas of the city.

Iron level at objectionable proportion in boreholes across various formation of Benin town was noted by Ohaji and Akujieze(1989).The source of iron in these boreholes according to them could be traced to geology of the ferrugised formation, drilling method, size of submersible pumps and quality of pipes used in the distribution.

VII. Seasonal Effect on Groundwater Pollution

Season is believed to influence the concentration level of the physico-chemical and bacterialogical loading in water sources.

Agbaire and Oyibo (2009) investigated seasonal variability of physico-chemical elements in boreholes in Abraka town. The result show total dissolved solids were lower in the dry season. Ocheri et al(2010) assessed seasonal variation in nitrate level in Makurdi metropolis and found 80% of the wells had nitrate concentrations above the WHO allowable limit for drinking water for wet season. Other parameters whose concentrations were higher in the wet season are pH, turbidity, electrical conductivity, chloride, iron, calcium, chromium, biochemical oxygen demand and faecal coliform bacteria. Nwafor et al(2013) anlysed the seasonal influence on the physico-chemical concentrations in hand dug wells in Akure town noted, of the parameters studied, pH, total dissolved solids, total alkalinity, potassium, iron, sulphate have higher concentrations in the wet season. Whereas, temperature, turbidity, total hardness, chloride, magnesium, electrical conductivity, sodium, nitrate have higher concentrations in the dry season.

VIII. Groundwater Pollution Mitigation Measures in Nigeria

Groundwater pollution in Nigerian urban emanates mainly from two sources; physical processes and anthropogenic activities. It is generally believed that once groundwater is polluted is difficult to remedy or very expensive to treat. Preventive measures are often recommended. Suggestions put forward in this respect are as follows:

There is the need for continuous monitoring of Nigerian urban groundwater to determine its quality status. This will serve as a guide to the public and water managers on action plans to be taken.

All landuse activities capable of polluting water sources both surface and underground should be properly regulated to safe guide their quality.

There should be protection of water sources and water points. Indiscriminate dumping of wastes into water sources should be prevented and hand dug well should have protective covers and sanitary environment kept free of stagnant waters and animal/human defecation.

Industrial effluents to be properly treated before they are discharged to avoid polluting water sources Sanitary landfills and waste disposal sites to be properly designed and constructed. Wastes generated should be promptly removed and disposed of.

Groundwater exploitation systems such as boreholes and hand dug wells should only be sited after proper sanitary inspection and approved recommendation.

Appropriate measures should be taken to treat the water by way of disinfection, filtration and boiling to safe guide drinking water quality.

There should be strong legislation on pollution of water sources. Perhaps polluter pay principle and good practice should be adopted.

IX. Conclusion

Studies have shown that Nigerian urban groundwater quality is under pollution threats from geology and the geochemistry of the environment, rate of urbanization, landfill/dumpsite leachates, heavy metals, organic matters and influence of seasons. This portends a danger of health hazard of utilizing groundwater for drinking water without any form of treatment. This calls for appropriate measures to protect and remedy polluted groundwater for safety purposes.

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