Peter, J Hydrogeol Hydrol Eng 2020, 9:4
DOI: 10.37532/2325-9647.1000202

Journal of Hydrogeology & Hydrologic Engineering

Research Article

A SCITECHNOL JOURNAL

Impacts of Anthropogenic Activities on Ground Water Quality in Onitsha city, Anambra State, South Eastern Nigeria

Peter Nkashi Agan*[1], Isabella Olije Akoji[1]

Abstract

Ground water is transitional water that interfaces between the surface and ground. It infiltrates into the soil and percolate through various soil strata before reaching ground aquifers and water table. Ground water is contaminated through dissolved liquids from the surface, ocean salt water intrusion and contacts with natural occurring mineral substances present in soils. The movement of water between the surface and the ground helps in the recharge and discharge of water, sustenance of the ecosystems and aquatic lives and serves as a potential source of water for domestic and industrial uses. This study aimed to investigate variation in ground water contamination in Onitsha with a view to unraveling the main contaminants present in ground water.

Forty water samples were extracted from wells in Onitsha metropolis and analyzed for the presence of Arsenic (Ar.), Cadmium (Cd), Lead (Pb), Mercury (Hg), Water Hardness, Temperature(T) and Potentials of Hydrogen (pH) using Atomic Absorption Spectrophotometer (AAS). The findings all affirmed a nexus between subsurface transport pathways and ground water receptors as the cause of contaminants between surface water, aquifers and water table.

The sources of these contaminants are commercial activities and dumping of waste in gutters. These inferred that ground water in Onitsha city is highly contaminated with Arsenic, Lead, Cadmium and Mercury which makes city water unsafe for drinking and must require purification before utilization.

Keywords

Ground Water; Water Table; Surface Water; Contaminants; Aquifers; Anthropogenic Factors; Correlation.

Introduction

Groundwater permeates into the soil and accumulates in pores and cracks of the earth's crust saturated zone of aquifers and aquitards and in unsaturated areas where pockets of air contains water [1,2]. Ground water constitutes over 97.5% of total fresh water supply (eight to ten million cubic kilometers) of which 2.5% is contributed by soil moisture, atmospheric vapour, soil seepage and surface water in streams, lakes and rivers etc. It is ubiquitous and depends wholly on geomorphology, geology, precipitation and land use for its quality, quantity, recharge and accessibility. Ground water is a major source of the world's drinking water (where half lies below depths of half a mile less than a thousand-feet) and not spatially distributed globally [3,4,5].

Ground water is a valuable resource for mankind and the survival of the ecosystem. It is used for domestic, industrial, agricultural, spiritual, cultural and sustenance/survival of the ecosystem; where as in desert areas ground water is the only source of portable water for domestic use and for recharging of rivers and wetlands during the dry seasons. The reasons for the significance of ground water to life and the ecosystems are not far-fetched; it is more reliable and closer to the users, insulated to pollution and vagaries of climate and surface water, clean, safe and a major source of water to 80% of the Globe [1,6,7].

However, ground water is contaminated when ground water receptor and subsurface transport pathway meet to initiates an infiltration of polluted surface water; caused by leaked sewer lines, industrial and municipal wastes etc. This permeated water mixes up with large dissolved pollutants and establishes contacts with aquifer systems reducing ground water quality. Ground water quality are also altered by ground water chemistry, ground water rock interaction, local geology and residence time in the aquifer. These interactions between ground water and materials in the geological strata is the cause of the large dissolved constituent found in ground water than surface water. These complex interactions between surface and ground water is caused by direction and magnitude of flow between surface water resources and water found beneath the surface. A hypothetical case is when a drainage basin or wetland loses and gain water between the ground (aquifer) and surface through seasonal, intermittent and ephemeral ways [1,7,8].

These exchange affects the quality and quantity of ground water resources which are transported to several discharge sites for drinking purposes, farming and other ecosystem values necessitating the assessments of ground water resources for future potential risk. These assessments are; hydro-geology of the water, hydraulics within the aquifer and the cation and anion characteristics within the aquifer etc [9]. Quality of ground water is influenced by both natural and anthropogenic forces, natural factors are weathered bedrock materials, evapotranspiration and deposition of salt and dust through wind and natural leaching of organic matter/soil nutrients while anthropogenic factors are manifold and they are; use of synthetic fertilizer, waste water treatment plants, manures, industrial sites, mining areas, uncontrolled waste disposal sites, heavy metals/evaporated petroleum, products/metal plating waste and oil plants sites etc. Other impacts are urbanization which transforms and initiates new abstraction points and changes the pattern and rates of ground water recharge through geochemical, physical and hydrological condition of the area [5,9,10].

Impacts of anthropogenic activities on ground water quality revealed high concentrations of pollutants in proximity to human activities. For examples, Nigeria's major sedimentary basins which defines the physical landscapes of the country (are the Delta-Niger, Sokoto, Benin and Benue crystalline basements complexes) all revealed high concentrations of dissolved solids for ground water. For example, high nitrates in the Sokoto Rima basin; chlorine in Lagos

***Corresponding author:** Peter Nkashi Agan, Department of Geography, Faculty of Science, University of Ibadan, Nigeria, Tel: +2348166207854; E-mail: aganpee@gmail.com

Received: August 14th 2020 **Accepted:** August 21st 2020 **Published:** August 28th 2020

aquifer due to sea water intrusions; copper, iron and leads in hand dugs wells and bore holes close to poorly disposed landfills in Ojota area; fecal and total coliform, aluminum, cadmium, lead and nickels in Ibadan due to nearness to abattoirs, pit latrines and drainage sites; manganese, calcium, total dissolved solids and coliform in wells close to dump sites and poor sanitary conditions in Makurdi; iron, chlorine and acid caused by salt water intrusion in the delta Niger area and nitrates, acids, sulphates and coliforms in Calabar wells due to urbanization [10]. Given the above problems, it is imperative to investigate ground water contamination in Onitsha metropolis with the view to identifying the human precursors that alters the water quality. The aim of this research is to investigate the nexus between surface and ground water contamination caused as a result of anthropogenic activities in the city of Onitsha.

Conceptual Framework

Ground Water Movement

Ground water movement is a complex form of transitional interaction between the surface and ground water within the hydrological system. Water from precipitation and lakes, streams and plants driven by potential energy (the combination of pressure and elevation) first infiltrate the top soil and percolates vertically and laterally through the various soils strata until it establishes contacts with the water table. This Water flow along path of different length from areas of recharge(source) to areas of discharge(outlets). The speed of movement is determined by the level of hydraulic gradient(permeability) of the soils or the rocks in the zone of saturation which affects the input of chemical(dissolved) discharged into lakes and wetlands. They also serve as a pathway for chemical interaction between terrestrial(surface) and aquatic system [11].

The outcome is both positive and negative; positive determines the level of recharge between surface and ground water which sustains the ecosystems and the negative is the contamination which can be transferred to the ground water system. When contaminated surface water recharges an aquifer then the water table beneath the aquifer becomes contaminated. E.g. of mediums of contamination are surface dissolved liquid substances, oceans salt water intrusions and contacts with naturally occurring minerals. These contaminants percolate into the soils and eventually come into contacts with aquifers and water tables polluting them in the process. If the process is continuous then a plume is formed within the contaminated area which has the propensity to affects large volumes of ground water areas. A clears example is the super fund sites where over 88% of ground water are contaminated. Alaska Department of Environmental Conservation [12] and (http://www.epa.gov/superfund/students/clas_act/haz-ed/ff_05.htm).

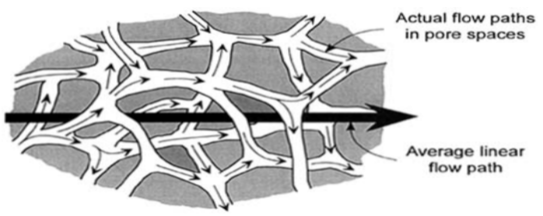

Figure 1: Well Hydrograph of Charethi monitoring well (UK-HP-6).

The rates of contamination of ground water is determined by water movements controlled by pores sizes, degree of interconnections and through fissures and grains spaces of rocks. This flow follows a close system tripartite dimensions which shows their entry into an aquifer and exits points. Water infiltrates the soil and percolates into the various strata of soils where hydraulic heads reduces with high and saturated flows beneath the water table and then exits the aquifers through springs, base flows and swamps in discharge areas, where hydraulic heads increases with depth and saturation flows [13]. Swamps, rivers, lakes are timely seasonal discharge and recharge points of ground water movements of which a little change in the quantity of recharge will also affects the rates of discharge which can influence the dissolved contents of temperature, oxygen and mineralization of aquatic and riparian bio-ta [11]. Below is an example of a ground water flow system culled from [14].

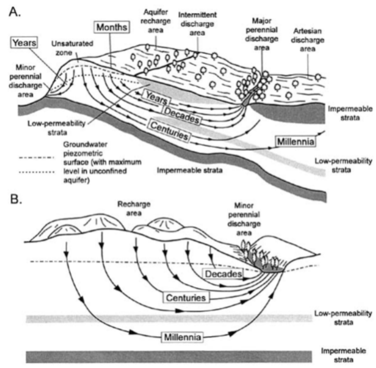

Figure 2: Ground Water flow systems of a Humid Regions in Figure A and an Arid region in Figure B. (Culled from Foster and Hirata, 1988).

Darcy Law

Darcy Law states that the rates of flow of water is directly proportional to the hydraulic gradients. It is represented:

Q = KA (dh/dl)

Where:

Q = Discharge Flow Through a Porous Medium

K = Hydraulic Conductivity (length/time)

A = Cross-Sectional Area (length)

Dh = Change in Hydraulic Head Between Two Points (Length)

Dl = Distance Between Two Points (Length) [13]

Literature Review

Kanchana et al [15] assessed the spatial distribution of ground water quality in Negombo-Muthurajawela area in Sri Lanka using 116 dug wells and selected thirty-one dug wells for physiochemical analysis. In place testing of salinity, PH, electrical conductivity and laboratory analysis were performed for $PO4_{3-}$, Na+, K^+, HCO_{3-}, Cl^-, $SO4_{2-}$, Ca^{2+}, Mg^{2-}, NO_{3-} and total hardness (TH). The quality of the water sample was determined using principal component analysis(PCA) which revealed a tripartite component in the thirty-one observations and they are; based on the impact on EC, HCO_{3-}, Na^-, K^+, Cl^-, $Mg2^-$, and TH; based on the pH, HCO_3, Ca^{2+}, $SO4_{2-}$, $PO4_{3-}$, and TH; and finally based on NO3− which elucidated the role of salt water intrusion, anthropogenic discharges and the Muthurajawela influence on Negombo-Muthurajawela area ground water quality.

Zaryab, et al [16] assessed the ground water quality and quantity trends in Kabul city aquifers estimated at 44 million m3/year in 2015 with abstraction of over 120,000 m3/day and water demand of 123.4 million m3/year to a quarter (25%) of 4,089,000 inhabitants at a per capita consumption of 50 lit/day, and discovered high levels of nitrate, 52% of (water sampled), boron (76% of water sampled), sulphate, chlorine and sodium above WHO standards. Faecal (coliform) bacteria increase in 58–70% of the wells sampled and decline in a groundwater level (1.7m) per annum was observed between 2008 to 2016 due to population growths and unsustainable and uncontrolled groundwater abstractions and contamination (by sewage).

A Study by Chakrabarty and Sarma [17] evaluated the levels of heavy metal contents in drinking water in Kamrup district, Assam India with respects to copper, zinc, cadmium, lead, arsenic and manganese in deep tube wells and ring wells covering the major hydrogeological areas using the atomic absorption spectrometer and the Perkin Elmer analyst 200. Their finding revealed high contents levels of cadmium, lead, arsenic and manganese in most of the drinking water samples collected in contrast to copper and zinc found to be within the WHO standards limits for safety. A close affinity was found between manganese, zinc and copper in terms of their source of origin and mobility Lu et al [18] investigated the impacts of anthropogenic activities (rapid urbanization and industrial development) on the pearl river for a period of two-decade with emphases on the hydro chemical characteristics' quality and heavy metal sources. Electrical conductivity, total dissolved solids, heavy metals, major ions and acidic contents (PH) were analyzed in twenty-five samples of water collected from the river. The TDS results ranged from 35.5 to 8,779.3 mg\$$L^{-1}$ and the major ions contents were dominated by feces and ranged from Cl^- >HCO_{-3} >Na^+ >$SO2_{-4}$ >NO_{-3} > NHþ ^{4} > Ca^{2+} > K^+ > Mg^{2+} > $Fe^{2+/3+}$ > Al^{3+}. Ca-$MgHCO_3$ and Na-K-HCO_3 while the chemical characteristics elucidated chemical weathering of the basement complex rocks through the interface of fresh and sea water. The heavy metal index (HPI) showed a 16% medium category, 20% high category and 64% low category which further highlight the urgent need for water purification before drinking. Other results showed the different sources of the physicochemical contents of the water which are lead, arsenic and manganese from landfill leachate, cadmium from landfill leachate and agricultural waste and chromium from industries which classified the water as the best for irrigation with minimal negative impacts and unsuitable for human consumption for over 9 million inhabitants of the Guangdong province.

Elisante and Muzuka [4] reviewed the occurrence of nitrate in Tanzanian groundwater aquifers and discovered that levels of concentration of nitrate in many ground water aquifers in Tanzania were above the 10mg/l background levels and WHO recommended levels for safe drinking water. Elevated levels of nitrates at 400mg/l were recorded in large urban centers of Dar es Salaam, Dodoma and Tanga cities. In most internal basins especially the Hombolo sub basin in Dodoma, nitrate concentration is 449mg/l and 445mg/l within the city of Dares Salaam and Arusha and Tanga. Poor sanitary system like the pit latrine was responsible for the elevated level of nitrate which decreased from the densely populated urban areas to sparsely populated rural areas where excessive use of inorganic and animal manure fertilizer is practiced.

A study by Chung-Mo, et al [19] evaluated the water policy of Korea for supplying safe drinking water for rural areas by exploring water quality test, well interior detection, environmental surveys, exploration and exploitation of drinking water facilities and the selection of a pilot project for water supply amongst high density pollution areas. They examined the synopsis of the safe ground water supply projects from 2014 to 2016 which provided quality water inspection for the rural populace who harvest water from old unregistered wells due to the high cost of testing equipment. The water quality analysis test revealed high concentration of contaminants ($NO3^{-N}$ and total coliforms) over the country's and WHO drinking water standards. They recommended the siting of a cheap public drinking water wells in pilot areas and some monitoring mechanisms for constant survey of the contamination status for the health care of the rural populace.

McLeod et al [20] examined the employment of principal component analysis (PCA) and kriging to predict groundwater quality across southern Saskatchewan to identify the nexus between chronic diseases and water quality. Water samples collected from private and public wells all exceeded the standards and objectives set by the province of the SK for water supplies quality. Arsenic contaminants were more in both wells accounting for 7% in public wells and 13% in private wells exceeding the health standards of 0.01mg/. Nitrate and selenium showed strong affinity with the PC_1 health for private and public wells; uranium was strongly linked with PC_3 health in public supplies and with PC_1 health in private wells; lead showed strong affinity with PC_1 health in public supplies and PC_3 health in private wells. Aesthetics objectives showed greater frequency than the health standards necessitating the constant monitoring of water samples from both private and public wells in Saskatchewan (SK). Bayesian kriging showed more accuracy in predictive values that ordinary and universal kriging.

MacDonald et al [21] used residence time to identify trends in ground water quality in the Permian aquifer of Dumfries Scotland where sandstone and breccia aquifer plays strategic roles in the water supply of Scotland. The age and quality of the ground water were investigated using conventional hydro geochemical techniques with CFC and SF 6 as residence time markers. Isotopes revealed that inter-bedded sandstone were older and replete with fossil water and nitrate formed from recharge rate of aquifer. Also, the variation in the water quality was influenced by time as modern ground water contained 9mgl and 1 in $NO3^{-N}$ while the pre-1950 groundwater contained 2mg l and 1 in $NO3^{-NOT}$.

In Nigeria, Isikhueme and Omorogieva [3] evaluated the hydro geochemical and biophysical characterization of groundwater in Onitsha and environs and revealed that most wells are contaminated with high levels of Barium, Iron, Manganese, Zinc, Chlorine and Phosphate above the threshold levels. No impacts of colour, total dissolved solid(TDS), dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), anions and cat ions were observed but the presence of turbidity and alkalinity of the some of the wells were traceable to the percolating leachate from the dumpsite, industrial activities and commercial land uses. The chemistry of the groundwater indicated low dissolve solute and low salinity and presence of heavy metals and microbial elements indicated prior treatments before its utilization by livestock.

Ezaebasili et al [22] investigated the levels of heavy metals concentrations in ground and surface water and their health impacts in Onitsha and discovered a high concentration of arsenic, cadmium, lead, mercury, zinc, copper and iron from ground and surface water which are closer to refuse dumps, industrial effluent, sewage, fuel spills, mechanic workshops, hospitals and pharmaceuticals wastes, agricultural materials, fossil fuel combustion, metallurgical industries, batteries, pigments, electronic components and some conductors. These elucidated that heavy metals concentrations were more on these sites than other less urbanized sections of the city. A study by Emelumadu, et al [23] evaluated the practice, pattern and challenges of solid waste management in Onitsha metropolis by interviewing 425 households of mean ages of 36.84 ± 12.21 years mostly males (258 and 60.7%) who are traders (50%) with minimum secondary education selected through multistage sampling techniques. Their findings revealed the use of government facilities by 57.4% (244), dumps sites and drainage by 11.1% (47) and some form of waste segregation by 60.90% (295) which encourages the spread of mosquitoes, house flies and other infectious diseases. Also, the irregularity in the collection pattern, non-availability of waste collection centers, inadequate funding by the governments and the ill treatments of waste collection personnel were challenges militating against the successful evacuation of refuse in Onitsha metropolis.

A study in Agbor area of delta state by Olobaniyi et al [24] investigated the hydro geochemical and bacteriological qualities of groundwater and revealed a low chemical attributes of salinity, acidity (PH) and total dissolved solids (TDS) with cation concentration of Na^{+} (0.9 to 18.9 mg/l), K^{+} (0.1 to 4.2 mg/l, Ca^{2+} (1.2 to 12.8 mg/l), Mg^{2+} 0.2 to 3.5 mg/ l), Fe^{2+}(0.08 to 1.92 mg/l), Zn^{2+} (0.12 to 4.35 mg/l), Mn^{2+} (0.0 to 0.42 mg/l) and Pb^{2+} (0.0 to 0.04 mg/l) and anions concentrations of HCO_{3-} (1.0 to 10.0 mg/l), CO_3^{2-} (0.1 to 0.9 mg/l), Cl^{-} (3.2 to 24.0 mg/l), SO_4^{2-} (0.0 to 10.3 mg/l), NO_3^{2-} (0.0 to 18.4 mg/l) and PO_4^{2-} (0.0 to 2.4 mg/). The bacteriological components of the sampled water revealed a count of aerobic bacteria (5 - 535cfu/ml) and coliform (10-70MPN/100ml) which are suitable for crop cultivation and unsuitable for domestic and industrial consumption (food processing) without prior PH remediation and microbial disinfection. Factor analysis elucidated a tripartite of hydro geochemical activities within the ground water systems which are water soil interaction and incorporation of leached formation along the water flow path, agricultural pollution of biochemical substances and fresh recharge of ground water dominated by chlorine (Ca-Cl, Ca-Mg-Cl, Mg-Ca-Cl, Na-Ca-Cl and NaCl) and bicarbonates (Na- HCO_3 and Na-Ca-HCO_3).

Okumagba and Ozabor [25] evaluated the effects of socio economic activities on the quality and quantity of river Ethiope in delta state which comprises (Umuaja, Umutu, Obi – Iloh, Ebedei-Ukwale, Owa-Abbi, Obinomba, Obiaruku, Umeghe, Urhuoka, Abraka P.O., Ajalomi, Urhuovie, Erho, Oria, Sanubi, Eku, Igun, Okpara Waterside, Ekpan- Ovu, Aghaiokpe, Arabga-Okpe, Adarweran, Egbeku, Ibada, Eko , Amukpe, Okirigwhre, Sapele, Jesse and Oghara communities) and elucidated that socioeconomic activities is the reason for the deteriorating quality of the river Ethiope which has a negative effects on the health of the inhabitants. The activities are 95% recreational mostly motels and hotels, 45% farmers both poultry and crops, 55% for washing and sewage dump, 35% for drinking and 20% for waste disposal.

Materials and Methods

Study area

Onitsha is located on the western fringes of Anambra state of Nigeria on Lat. 6°78'N and 6°86'N and long. 6°47'E and 6°49'E. It is bifurcated into two local government areas namely Onitsha North and South and bounded to the East and North East by Idemili North and Oyi Local Government Areas, to the North by Anambra West and to the South and South West by Ogbaru Local Council Areas. Onitsha is watered by the great Niger river to the West and also serve as the natural boundary between Anambra and Delta states. It has an aerial extent of 50km2, situated 50m above mean sea level on the dip slope section of the east facing scarp slopes of the Awka-Orlu cuesta landscape, underlain by flood plain deposits and coarse fine grained Nanka sands of the Bende-Ameki formation of the Eocene era [26,27].

Onitsha literally means dispersal and was founded between 1630 and 1680 by immigrants from the old Benin empire after an inner fracas that existed at the time. Since then, the city has geometrically expanded in areal extent and population. Onitsha is the melting points of the trans Saharan trade route with the upper Benue valley, the trans-Atlantic trade route with the forest communities of Nembe, Kalabari, Aboh and the southern littoral areas. The main commodities traded are dried fish, spices and agricultural produce between the hinterland communities of old and the riverine communities. The city grew after the expedition of Beikie and McGregor Laid and other European companies who established trade and the spread of western education through Christian missionaries notably Samuel Ajayi Crowder [26,27,28].

The climate of Onitsha city is defined by sub-equatorial and tropical hinterland climate influenced by the warm moist south-west trade winds which ushers in the wet season between the months of April to October and the north-east trade winds which brings in the dry dusty harmattan between the months of November to March. Onitsha has an average temperature of 26°C with maximum temperatures felt more between the months of December to March and minimum temperatures experienced between the months of June to September. The rainy season is usually high at an average of 1,850mm per annum between the months of March to November and consequently the vegetation is light forest with minimal tall trees and grasses of both hardwood and soft species on the verge of extinction due to land development with only a semblance of alluvium vegetation in the riparian areas. The geology of Onitsha is dominated by a vast sedimentary basin of the Niger Benue trough of the upper middle Eocene strata called the Bende Ameke group and the Orlu cuesta which ends at the Fringes of the Niger river bank. Notable rivers such as Nkissi, Anambra and the Idemili defines the landscape of the city and are drained into the Niger river.

Residentially and commercially, Onitsha houses the largest market in west Africa, the most industrialized, cosmopolitan and highly religious with major denominations in the city such as the Catholics, Anglicans and the non-Christians minority. The residential areas are dominated by non-indigenes who make up over three quarter of the population while the aborigines occupy the inland town portion of the city. Notable residential areas are the Awka, Oguta, New and Old Market, Iweka, Venn, Court, Park, Old and New Cemetery roads and the Modebe Avenue. Others are the American Quarters, Fegge, Woliwo, Odoakpu and Omagba areas. The commercial and by extension the industrial status of the city pervades environmental challenges which are pollution from industries and commercial land uses and indiscriminate disposal of industrial, commercial, medical and domestic wastes into water bodies [3,28].

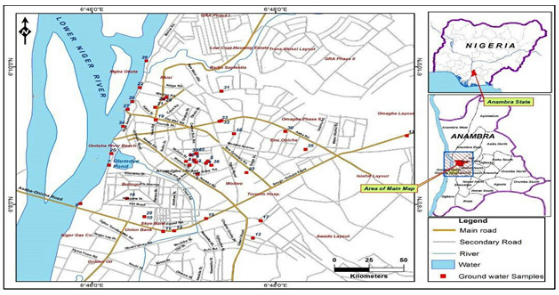

Figure 3: Study Area.

doi: 10.37532/2325-9647.1000202

Data Sources

Primary sources of data were used for the study; forty water samples were randomly collected from forty boreholes with a depth of 15m during the end of the wet season in the month of October in Onitsha City.

Analytical Methods and Steps

Forty water samples collected were stored in a sterilized 500ml screw capped properly washed glass bottles and transported in ice park for immediate analysis. Thereafter, heavy metals like Arsenic (Ar.), Cadmium (Cd.), Mercury (Hg.), and Lead (Pb.) and non-metals like Hardness, Temperature(T) and Acidity(pH) were all analyzed using Atomic Absorption Spectrophotometer (AAS). Atomic Absorption Spectrophotometer (AAS) works based on absorption of radiant energy in ultra violet and visible regions in gaseous state by neutral atoms. Atomic absorption spectrophotometer analysis uses: Varian instruments, analytical grade chemicals (e.g. HNO_3, Sigma chemicals, Australia, Standard heavy metals solution) and 70% pure nitric acids (used for fast sequential and AA210FC after 4°C preservation for a limited period of time and digested through APHA methods). Finally, the concentration for both heavy metals and non-metals were revealed and recorded.

Results and Discussions

Correlations between Heavy Metal Concentrations and Physicochemical Parameters of Water

The concentration of lead as showed in Table 1 ranged at 0.49mg/l between 0.15mg/l and 0.64mg/l and a mean of 0.40mg/l, Arsenic at 1.97mg/l between 0.00mg/l and 1.97mg/l with a mean of 0.29mg/l, Cadmium at 2.01mg/l between 0.00mg/l and 2.01mg/l and showed a mean of 0.60mg/l and mercury range of 1.9mg/l between 0.00mg/l and 1.91mg/l and a mean of 0.96mg/l. These results reveal high concentrations of all elements above the WHO recommended limits for safe drinking water. Lead concentration of 0.49mg/l is higher than the WHO level at 0.1mg/l, arsenic concentration with WHO level at 0.01mg/l is at variance at 1.97mg/l recorded. Also, the concentration of cadmium at 2.01mg/l is higher than the WHO guideline of 0.01mg/l while mercury which has a WHO guideline of 0.001mg/l recorded 1.91mg/l marked difference. This shows that all the water sampled are not safe for drinking and will require purification before drinking.

From the results it can be affirmed that subsurface transport pathways have a direct contact with the ground water receptors which transports contaminants into aquifer and contaminates the water table. Groundwater contains both natural and man-made occurring chemicals which exist as dissolving traces and in suspended large quantities. Ground water quality is determined by mineralogy of the rock types, aquifers, overlying land uses, proximity to the coast, recharge water sources, aquifer structure, soil type and residence time of the water. These levels of contaminants revealed high impacts of anthropogenic activities on ground water quality in Onitsha metropolis. The pH level ranged at 2.5 between 6 and 8.5 with a mean of 7.24. This reveal that the alkaline contents of the water sampled is in-crusting other and contains a higher dissolved solid. Most of the sampled water are partially acidic due to the high presence of mercury, lead, cadmium and arsenic. In terms of hardness all the sampled water recorded a range of 38 between 62 and 100 and a mean of 80. 33ppm.This indicates low levels of calcium and magnesium ions in the water. The temperature of the water ranged at 2.4°C between 27.2°C and 29.6°C. The higher the temperature the higher the changes in the total dissolve solids and the lower the temperature the lower the changes in total dissolve solids. The temperature of the sampled water ranged at 2.4°C between 29.2°C and 27. 2°C against the WHO recommended levels of 25°C. The hardness limits of 500ppm at the WHO recommended limits is higher than the sampled water at 38ppm.

Ground water contamination is caused by the interaction between subsurface transport pathways and ground water receptors. This comes from the movements of contaminated surface water to the ground reducing the quality of the ground water. To determine this nexus, regression analysis was employed between variables to determine the cause effects relationships and their impacts on ground water. The contaminants of lead, mercury, cadmium and arsenic were tested with hardness, levels of H+ and temperature.

From Table 2, Mercury and temperature revealed R as 0.003, R^2=1.02, F=0.0004 and the p value as 0.86 suggesting an insignificant relationship between mercury and temperature. For Mercury and pH levels the following were revealed; R=0.48, R^2=0.23, F=11.47 and p value =0.002 which means that there is a cause effect relationship mercury and pH. Mercury and hardness level showed R=0.26, R^2=0.07, F=2.68 and p value of 0.11 at 0.05 significance level which inferred that mercury has no influence on the hardness of the water sampled. Cadmium and hardness revealed R =0.16, R2=0.03, F=1.02

Table 1: Physico-Chemical Analyses of Water Samples.

	N	Min	Max	Mean	Std.Dev.	Variance	Skewness	Kurtosis
Lead (Pb)	40	0.15	0.639	0.398	0.115	0.013	0.549	-0.098
Arsenic (Ar)	40	0	1.965	0.293	0.476	0.227	1.921	3.196
Cadmium (Cd)	40	0	2.01	0.601	0.646	0.417	0.813	-0.192
Mercury (Hg)	40	0	1.91	0.959	0.831	0.692	-0.08	-1.944
Hardness	40	62	100	80.33	12.259	150.27	0.07	-1.426
Température(T)	40	27.2	29.6	28.4	0.654	0.428	-0.153	-1.293
Potentials of Hydrogen (pH) Levels	40	6	8.5	7.24	0.777	0.604		

Source: Field Work, 2017

and p value of 0.32 at 0.05 significance level which means that cadmium and hardness have no effects on each other. Cadmium and pH levels showed R at 0.40, R^2=0.16, F=7.22 and p value of 0.011 at 0.05 significance level suggesting that cadmium has no influence on pH levels.

Table 2: Régression Analyses of Water Samples.

	R	R2	F-Value	p-value at 0.05
Mercury and Température	0.00319	1.022	0.000388	0.85
Mercury and pH Levels	0.481	0.231	11.467	0.00165
Mercury and Hardness	0.256	0.065	2.683	0.1096
Cadmium and Hardness	0.161	0.026	1.016	0.319
Cadmium and pH Levels	0.399	0.159	7.223	0.0106
Cadmium and Température	0.102	0.0105	0.404	0.528
Arsenic and Hardness	0.238	0.056	2.27	0.139
Arsenic and pH Levels	0.303	0.092	3.858	0.056
Arsenic and Température	0.047	0.0023	0.087	0.769
Lead and Hardness	0.062	0.0038	0.148	0.702
Lead and pH Levels	0.0066	0.0000044	0.00167	0.967
Lead and Température	0.041	0.0017	0.067	0.797

Source: Field Work, 2017

Cadmium and temperature showed R=0.10, R^2=0.011, F=0.40 and p value of 0.53 which suggest that cadmium has no influence on temperature. Arsenic and hardness reveal R=0.24, R^2=0.06, F=2.27 and p value of 0.14 which suggest that arsenic has no effects on hardness at 0.05 significant levels. Arsenic and pH levels showed R=0.30, R^2=0.09, F=3.86 and p value of 0.06 which means that arsenic has no influence on pH levels at 0.05 significant levels. Arsenic and temperature revealed R as 0.05, R^2=0.0023, F=0.09 and p value of 0.77 at 0.05 significant levels suggesting non-effects between arsenic and temperature. Lead generally inferred a non-significant relationship between variables. Lead and hardness revealed R as 0.06, R^2=0.004, F=0.15 and p value of 0.70. Similarly, Lead and pH levels showed R as 0.0066, R^2=0.00000441, F=0.0017 and p value of 0.97 while Lead and temperature revealed R as 0.04, R^2=0.002, F=0.07 and p value of 0.79 all suggesting no effects between variables.

Most of the wells sampled as showed in Figure 4 to Figure 6 above contains arsenic, mercury and cadmium which corroborates with prior studies in the city. Ezaebasili et al [22] reported high contamination of zinc, arsenic, cadmium and copper etc. in most wells in Onitsha and attributed it to the proximity of dump sites, industrial effluents, sewages, pharmaceuticals wastes etc. also the residence practices of dumping wastes in gutters, drainage, rivers and streams also impacted negatively on the water quality of the city. Similarly, high concentration of iron, boron, zinc was discovered in wells in Onitsha city by a study carried out by Isikhueme and Omorogieva (2015) and traced to the proximity to dump sites, industrial and commercial activities. Consistent with these, are studies by Chakrabarty and Sarma [17] which revealed high contents of cadmium, lead, arsenic and manganese in most wells in Kamrup District India. Also, Mclead et al [20] reported the high arsenic concentration in public wells in India as the major cause of water borne diseases in southern Saskatchewan district. These contaminants could be the reason for the cholera outbreaks and water borne diseases currently experienced in the city of Onitsha. Long term consumption of water with high arsenic contents above 0.01g/m3 is toxic to human health. These should be investigated to identify the correlation between ground water contaminants and human health status in the city.

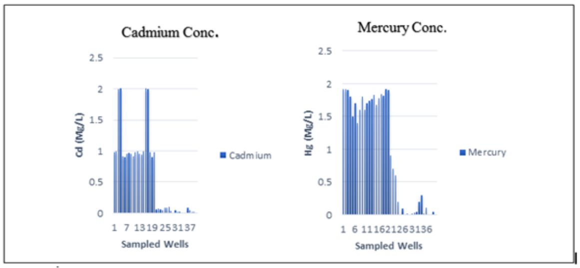

Figure 4: Mercury and Cadmium Levels.

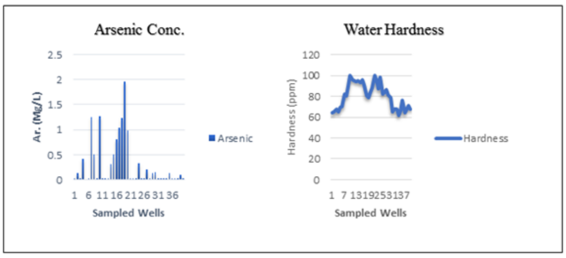

Figure 5: Arsenic and Water Hardness Levels.

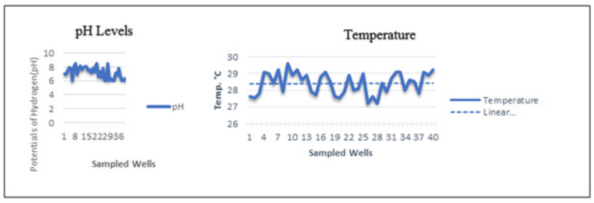

Figure 6: Température and pH Levels.

Conclusion

Ground water contamination is a contemporary issue that needs constant monitoring and investigation. The rates of urbanization and commercial activities in Onitsha are geometric due to rural/urban migration and economic development. The city houses the biggest market in West Africa and constantly grapples with problem of waste management. One aspect of this problem is the contamination of ground water during precipitation where surface water establishes contacts with wastes and transports their diluted contents into ground water through infiltration and percolation. This percolation travels through different strata of the soils depositing contaminants and eventually to aquifers and water tables. The cardinal aim of this research is to investigate the nexus between surface and ground water

doi: 10.37532/2325-9647.1000202

contamination through anthropogenic activities. The presence of non-biodegradable and unrecycled wastes in the city in proximity to water bodies calls for concerns as the health of the inhabitants are at risk.

Most of the wells investigated are highly contaminated with heavy metals such as; mercury, arsenic, cadmium and non-metallic materials. These non-metals materials like hardness, temperature and acidity needs to be further investigated due to their impacts on human health. The levels of acidity of the water samples are lower than the WHO recommended limits as against water hardness and temperature which indicated high contents of magnesium and calcium ions. There is a need for constant investigation of the ground water quality as the city is visibly sprawling into virgin lands due to population growth. As more people migrates into the city the demand for drinkable water will increase necessitating the constant drilling of bore holes and hand dug wells for water supply. These wells have geometrically increased and there is a need for future research to ascertain the current number of wells in the city for proper investigation of water quality for the safety of the inhabitants.

Conflict of Interests

The authors declared no conflict of interest.

Acknowledgements

PNA conceptualized the study, carried out the reconnaissance survey and prepared the manuscripts. IOA carried out the water sampling and participated in the reconnaissance survey too. All authors read and approved the manuscripts. All references are duly acknowledged.

References

1. Sonia C, Jason D, Ian R (2017) Using Monitoring Data to Assess Ground Water Quality and Potential Environmental Impacts. Department of Science Information Technology and Innovation (DSITI).
2. Van Der Gun J (2012) Groundwater and Global Change: Trends, Opportunities and Challenges. United Nation World Water Assessment Programs pp: 1 – 44.
3. Isikhueme MI, Omorogieva OM (2015) Hydro Geochemical and Biophysical Characterization of Groundwater in Eastern Nigeria: A Case Study of Onitsha and Environs. Nigerian Journal of Technology (NIJOTECH) 34: 875 – 882.
4. Elisante E, Muzuka ANN (2017) Occurrence of Nitrate in Tanzanian Groundwater Aquifers: A Review. J Appl Water Sci 7: 71–87.
5. Vrba J (2002) The Impact of Aquifer Intensive Use on Groundwater Quality. 113: 1-20.
6. Helen J, Ozdemiroglu E (2007) Assessing the Value of Groundwater.
7. Lapworth DJ, Nkhuwa DC, Okotto-Okotto J, Pedley S, Stuart ME et al. (2017) Urban Groundwater Quality in Sub-Saharan Africa: Current Status and Implications for Water Security and Public Health. J Hydrogeo 25: 1093–1116.
8. Pawari MJ, Gawande S (2015) Ground Water Pollution and Its Consequences. IJERGS 3: 773-776.
9. Vital Water Graphics, UNEP World Water Development Report 3 'Water in A Changing World'. WWAP, (2009)
10. Ocheri MI, Odoma LA, Umar ND (2014) Groundwater Quality in Nigerian Urban Areas: A Review. Global Journal of Science Frontier Research; Environment and Earth Science 14: 1-13.
11. Basic Groundwater Concepts, D W R – Bulletin 118
12. Alaska Department of Environmental Conservation (2009) Division of Spill Prevention and Response Introduction to Groundwater.
13. Chilton J (1996) Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring.
14. Foster SSD, Hirata R (1988) Groundwater Pollution Risk Assessment. Lima pg:73.
15. Kanchana CM, Chandrasekara NK, Weerasinghe KDN, Pathirana S, Piyadasa RUK (2015) Impacts of Natural Processes and Human Activities On Ground Water Quality in the Negombo-Muthurajawela Region In Sri Lanka. J Appl Geo 1: 270-278.
16. Zaryab A, Noori AR, Wegerich K, Klove B (2017) Assessment of Water Quality and Quantity Trends in Kabul Aquifers with an Outline for Future Drinking Water Supplies. CAJWR 3: 3-11.
17. Chakrabarty S, Sarma HP (2011) Heavy Metal Contamination of Drinking Water in Kamrup District, Assam India. Journal of Environmental Monitoring and Assessment 179: 479-486.
18. Lu Y, Tang C, Chen J, Yao H (2016) Assessment of Major Ions and Heavy Metals in Ground Water: A Case Study from Guangzhou and Zhuhai of the Pearl River Delta, China. Journal of Earth Sci 10: 340–351.
19. Chung-Mo L, Se-Yeong H, Hang-Tak J, Moonsu K, Hyun-Koo K et al. (2017) Water Policy of Korea for Supplying Safe Groundwater in Rural Areas. Journal of Water 9: 1-15.
20. Mcleod L, Bharadwaj L, Epp T , Waldner CL (2017) Use of Principal Components Analysis and Kriging to Predict Groundwater-Sourced Rural Drinking Water Quality in Saskatchewan, Canada. Int J Environ Res Public Health 14: 1-25.
21. Macdonald AM, Darling WG, Ball DF, Oster H (2003) Identifying Trends in Ground Water Quality Using Residence Time Indicators: An Example from The Permian Aquifer of Dumfries, Scotland. J Hydrogeo 11: 504-517.
22. Ezeabasili ACC, Anike OL, Okoro BU (2015) Urban Water Pollution by Heavy Metals and Health Implication in Onitsha, Nigeria. African Journal of Environmental Sciences and Technology 9: 325-331.
23. Emelumadu OF, Azubike OC, Nnebue CC, Azubike NF, Sidney-Nnebue QN (2016) Practice, Pattern and Challenges of Solid Waste Management in Onitsha Metropolis, Nigeria. Am J Public Health Res 4: 16-22.
24. Olobaniyi SB, Ogala JE, Nfor NB (2007) Hydro Geochemical and Bacteriological Investigation of Groundwater in Agbor Area, Southern Nigeria. Journal of Mining and Geology 43: 79 – 89.
25. Okumagba PO, Ozabor F (2014) The Effects of Socio-Economic Activities on River Ethiope. Journal of Sustainable Society 3: 1-6.
26. Ikegbunam FI (2014) Onitsha Urban Road Transport System: Implications for Urban Transport Planning. International Journal of Applied Science and Technology 4: 1-7.
27. Izueke EMC. Eme OI (2013) Urban Planning Problems in Nigeria: A Case of Onitsha Metropolis of Anambra State. Singaporean Journal of Business Economics and Management Studies.
28. UN Habitats (2012) Nigeria: Onitsha Urban Profile by Alioune B., Falade, J. B. Okpala, D. Onweluzo, F. Ajayi, M. O. Ejindu, C. F. Okojie, C. C. and Ikenna, U. C. in Nigeria and Sommer, K. Grimard, A. Kithakye, D. Spaliviero, M., and Mbye, D. in Nairobi, Kenya.
29. Berstrom JC, Boyle KJ, Job CA, Kealy MJ (1996) Assessing the Economic Benefits of Ground Water for Environmental Policy Decisions.
30. Dennis N (2002) Natural Variations in the Composition of Groundwater.
31. Eisena C, Anderson MP (1979) The Effects of Urbanization on Ground-Water Quality — A Case Study of Milwaukee, Wisconsin USA. Journal of Ground Water Association 17: 456–462.
32. Plummer AN, Bexfield LM, Scott K, Bartolino JR, Cole JC (2003) How Ground-Water Chemistry Helps Us Understand the Aquifer, U.S. Geological Survey Circular 1222
33. The American Ground Water Trust Report Titled Earths Water in the American Well Owner (2002), No. 1 Adopted from the Rime of the Ancient Mariner by Samuel Taylor Coleridge (1798) and the Water Quantity Information from The Water Encyclopedia (2nd Edition 1990) Lewis Publishers, Chelsea, Michigan, USA.
34. Getting Up to Speed" For Section C, "Ground Water Contamination" Is Adapted from US EPA Seminar Publication. Wellhead Protection: A Guide for Small Communities. Chapter 3. EPA/625/R-93/002.

Author Affiliation

Top

Department of Geography, Faculty of Science, University of Ibadan, Nigeria