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Impact of Anthropogenic Activities on the Quality of Water Resources in Kaduna Metropolis, Nigeria

Aliyu Dadan Garba
Centre for Environmental Health Engineering
University of Surrvey, UK.

ABSTRACT
This work investigated the impact of anthropologic activities on the quality of water resources in Kaduna metropolis. The city has a population of 1.6 million people and has various landuses around both the main surface water body of river Kaduna and the groundwater sources. These landuses include residential, commercial, industrial, agricultural and civic. Water samples were collected at 12 sampling points (eight ground water and four surface water). Analysis of acidity (PH), temperature, electrical conducting, total dissolved solids, dissolved oxygen, biological oxygen demand, lead, oil and grease and coliforms were done. Results showed that values of electrical conductivity, total dissolved solids, coliforms and Lead were generally above the limits of regulatory bodies. The results also revealed very low level of dissolved oxygen. It also showed that domestic and industrial areas as well as irrigation sites were found to be most contaminated. Surface water has more trace elements, while ground water sources have more physico-chemical values in all the study.

KEYWORDS: *contamination, Kaduna, Landuse, Parameters, Anthropogenic*

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I. INTRODUCTION

Water pollution is an important aspect of environmental pollution considering the necessity of water for existence. Water pollution has impacts on not only humans but also animals, micro-organisms and plants through the intake of water by the living organisms. The importance of water notwithstanding, it has long been recognised as a vehicle for the spread of many diseases (Wijk-Sijbesma, 2002 and Sawyer *et al.,* 2003). These diseases include the worst outbreak of *Escherichia coli* in Canada (Kondro, 2000) and *Cryptosporidium* in Milwaukee, Wisconsin, USA in 1993 (Hoxie *et al.,* 1997).Water sources both surface and groundwater are often contaminated by anthropogenic activities. These include discharges of agricultural, industrial and municipal wastewaters into water courses which ultimately reach the aquifers. Among the pollutants are nitrates from domestic sewage and fertilisers and pesticides in agriculture (Salvato *et al*., 20003). Others are livestock farming that transmits pathogens from animal manure and fish farming that exacerbate eutrophication by adding biochemical oxygen demand and nutrients to the local environment (Kirby *et al.*, 2003). Water pollution usually refers to natural processes and events that cause the contamination and impairment of water for its intended use. These natural events such as torrential rainfall and hurricane cause excessive erosions, flooding, tsunamis and landslides, which in turn increase the content of suspended materials in affected rivers and lakes leading to little or no dissolved oxygen among other consequences (Meybeck *et al.,* 1996). Groundwater quality problems may arise from natural phenomena or due to human activities. The principal groundwater quality issues relate to excess hardness and the presence of iron, manganese, chloride, nitrate and coliforms (Purcell, 2003, Kiely, 1996).

Surface waters are affected by among others microbiological pollution through such human activities that generate human wastes and municipal wastewaters, industrial wastewaters as in food, beverage, abattoir and meat packaging. These activities invariably contain faecal materials that may include pathogens (Taylor, 2003).The impairment of water is usually referred to as pollution, contamination, nuisance or water (air, soil) degradation (Novotny, 2003). Regardless of the terminology or cause water pollution can be categorised as either point or non- point (Masters and Ela, 2000). Point sources are based on the activities that produce the pollutants such as from a specific, identifiable source, usually a facility and is released at a known discharge point or outfall, usually a pipe or ditch, a ship, municipal sewer system, industry and power plants. Non-point source pollution on the other hand arises from the way the pollutants are discharged into the environments which are non-specific. Amongst these are agricultural practices such as the applications of pesticides that are carried far away as runoff which ultimately contaminate groundwater through the soil profile particularly the unsaturated soil zone (Estevez et al. 2008).Mander and Forsberg (2000) reviewed works that showed that the most significant impacts of diffused or non-point pollution as being caused by agriculture (nutrients and pesticides); transport (roads, rail and shipping); atmospheric deposition (on lakes and seas); storm water from urban and industrial sites.

It should, however, be noted that except in few cases such as storm water due to rainfall most non-point source pollution began as point source and spread over time and space from specific points of origin to where they are domiciled.Regarding water quality there is no any source of water that is wholesome, free from contamination. Rainwater mixes with acids and organic compounds as it falls; surface water also comes into contact with pollutant discharges which ultimately infiltrates into the groundwater (Zeliger, 2008). Water pollution is a global problem which affects rich, developed and poor, developing countries; rural and urban environments. It is expected that pollution in rural areas would come more from agricultural and mining activities while sources such as manufacturing and power production would account for pollution in urban areas especially in developed countries. Younger (2001) stated that coal and other abandoned mines are second to sewage as sources of freshwater pollution in Scotland. In many coal field catchments it is the preeminent source. On the other hand in poor, developing countries pathogens associated with disposal of human wastes have been major sources of water pollution leading to water borne diseases such as amoebic dysentery, bacillary dysentery, cholera, hepatitis A, typhoid and polio (Sullivan *et al.*, 2005). And whereas in developed countries there are regulations regarding the release of effluents into water courses those regulations are non- existent or largely ignored in developing countries. In this regard Yassi *et al.,* (2001) reported the release of untreated liquid wastes into surface water courses in Alexandria, Egypt; Bogota, Columbia; Karachi, Pakistan and Shanghai, China.

Regarding the problems caused by water pollution, the World Health Organization in its 2009 report estimated that 80% of all infectious diseases in the world are associated with insufficient and unsafe water. UNICEF (2009) reported that 39% of world population (over 2.6 billion people) live without access to improved sanitation while 884 million are without improved water supplies. Consequently, more than 3.8 million, mostly children under five years of age die annually from pneumonia and diarrheal diseases (WHO, 2009).Nigeria as a developing country suffers from water contamination from anthropogenic activities. Studies have shown that the country's water resources have been contaminated from human activities such as industrial, agricultural and domestic activities in both urban and rural areas. The major contaminations affect chemical and microbiological parameters with contaminants ranging from trace elements, nutrients to coliforms.This work investigates the impact of anthropogenic activities on the quality of water resources in Kaduna Metropolis, Nigeria. This is due to the association of infectious diseases with unsafe and insufficient water (WHO, 2009). The contamination of water is largely caused by negative impacts of human activities on environmental parameters.

II. THE STUDY AREA

Kaduna metropolis is the capital of Kaduna State. The state is one of the 36 states that comprise the Federal Republic of Nigeria. The study area is composed of Kaduna North Local Government Area.The GPS co-ordinates of the study area range from latitudes 10 24.447N to 10 35.004N and longitudes 007 24.245E and 007 28.886E. According to 2006 national population census Kaduna State has a population of 6.066 million people. About 1.45 million people reside in the study area, representing about 24% of the population of the state.The study area is roughly located in the centre of the Kaduna River Basin. The area is underlain by Basement complex comprising high grade metamorphic and igneous rocks such as migmatite, mica, quartz mica, schist, granite gneiss, biotite, granite, coarse- porphyritic, biotite and diorite (Akujieze et al., 2003).The study area experiences the tropical continental climate (savannah) type of climate with two distinct yearly seasons. The dry season starts from middle of October to late April. The wet season begins from May to early October. The mean annual temperature stands at about 25^0C and annual rainfall at about 1200 mm (Mallo, 2000).

III. MATERIALS AND METHODS.

The objective of sampling was to determine the points from which water would be collected for laboratory analysis. To achieve this systematic sampling technique was chosen. This was to ensure that all sampling points were in locations that are representative of the land use activities. In addition to that, only activities that are sited within a close range of streams or those in whose vicinity hand dug wells are found were sampled. Consequently, sampling points were selected in 11 locations in the study area.Samples were collected in duplicates in all sampling points. . In the study water samples were collected from eight groundwater and seven surface water sampling points. Samples were analysed for physico-chemical, microbiological parameters, lead, oil and grease

(a) Groundwater sampling- in this method a container was tied to a rope and lowered into a well. Water was fetched at the water table and some depth below. The water was poured into sampling bottles filled to the brim, capped and tightened.

(b) Surface water sampling- to be able to collect samples from surface water particularly, perennial rivers, research assistants got into a canoe. Inside the canoe a container was lowered into the river against direction of flow. Content was then poured into sampling bottles, filled to the brim, capped and tightened.

pH- was measured using HANNA HI 991300. Prior to measurement the meter was calibrated. The mode button was pressed and held until 'CAL' was displayed on the lower LCD. This was followed by the display ''pH 7.1 USE''. To measure the pH, the probe was soaked in pH 7 solution at least one hour to reactivate the instrument. The pH mode was then selected with set/ hold button and submerged in the sample while stirring gently. This continued until the stability indicator on the top left of the LCD disappeared. The pH value was shown on the primary LCD while the second LCD displayed the sample temperature.

(b) Temperature- this was displayed on the second LCD when either the pH, EC or TDS was shown in the primary LCD.

(c) Electrical conductivity (EC)/ Total dissolved solids (TDS) - the probe was put in the sample and the EC mode was selected with the SET/ HOLD button. The probe was lightly tapped at the bottom of the container to remove air bubbles trapped inside the tip. After some minutes the stability indicator on the top left of the LCD disappeared. The meter showed the EC or TDS values on the primary LCD while the temperature was displayed on the second LCD.

(d) Dissolved oxygen (DO) - the analysis of dissolved oxygen is a key test in water pollution and waste treatment process control. The levels of DO depend on physical, chemical and biochemical activities in the water body.

Samples were collected in clean 300 ml glass BOD bottles. 1 ml $MnSO_4$ solution and 1 ml of alkaline iodide- azide reagent were then added, glass stoppered and inverted several times until floc has settled. 1 ml of H_2SO_4 concentrated was also added. The sample was then poured into a 250 ml graduated cylinder to the 200 ml mark, and then poured into a 250 ml conical flask. A 25 ml burette was used to fill 0.025N Sodium thiosulphate solution to the zero mark which was used to titrate the sample to a pale yellow colour. Two dropperfuls of starch indicator solution was then added and swirled to mix.

Titration was continued until solution changed to dark-blue to colourless. The amount of titrant used in ml was equal to DO mg/l in the sample.

(e) Biochemical oxygen demand (BOD) – this represents the amount of oxygen required by bacteria to decompose aerobically the organic matter. This decomposition happens under standard conditions of time and temperature. In order to minimise sample degradation in the determination of BOD the samples were stored in ice packs with temperature around 4^0C between sampling and analysis.

(f) Total and thermotolerant coliforms- appropriate dilutions of sample water with distilled water (1- 3 ml) were inoculated in duplicates by spread platting on eosin methylene blue (EMB) agar for the enumeration of coliforms. 1ml of the diluted sample was introduced into each of the petri- dish plates and 15 ml of EMB agar was poured into the plate. The plate was gently rotated to facilitate even distribution of isolated colonies.

(g) Lead (Pb) - the method used was Flame Atomic Absorption Spectrometry (FAAS), Model BUCK 210VGP.

(h) Oil and grease- Partition gravimetric method. In this method the determination was made by extracting a measured water sample with 1,1,2- trichloro, 1,2,2- trifluoro- ethane (Freon 113), evaporating the Freon 113 layer and weighing the residue to determine the specific concentration in mg/l.

IV. RESULTS AND DISCUSSION.

In the study, water samples were collected from a total of twelve sampling points (eight groundwater and four surface water). The results of laboratory analysis were subjected to statistical analysis with the aim of having a more meaningful data for discussion. The statistical techniques used were summary statistics which produced mean and standard deviation of all the parameters'

Table 3.1 Mean and range of parameters, Pilot study 1 sampling programme, June &July, 2009

2009	Mean (range) GW 1	Mean (range) GW 2	Mean (range) SW 1	Mean (range) SW 2	WHO	US EPA	NIG.GOVT
pH	6.44 (5.3 - 8.5)	5.93 (4.6 - 6.6)	6.8 (6.1 - 7.3)	7 (6.4 - 7.7)	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5
Temp [°c]	26.79 (26.1 - 27.9)	27.24 (25.7 - 28.3)	27.25 (25.9 - 30)	26.55 (23.3 - 29.5)			
EC [µS/cm]	524.29 (145 - 963)	542.36 (132.5 - 922.5)	307.13 (90.5 - 593)	224.38 (68.5 - 371)	250		1000
TDS [mgl]	379.14 (27 - 766)	361.86 (55.7 - 734.5)	243.75 (71 - 474)	123.33 (24.8 - 301.5)	1000	500	500
DO mg/l	2.82 (1.8 - 3.6)	2.87 (0.41 - 4.6)	2.78 (1.6 - 4)	2.47 (0.34 - 4.16)	9		
BOD mg/l	29.21 (2.9 -135.8)	18.28 (2.5 - 72.6)	173.68 (14.7 - 479)	156.48 (12.5 - 401)	20		
TC cfu/ml	48.57 (14 - 101)	65.57 (20 - 130)	77.75 (26 - 155)	86.75 (39 - 150)	0	0	0
Th.C cfu/100ml	14.57 (0 - 38)	33.57 (0 - 194)	11.25 (4 - 29)	21.25 (0 - 81)	0	0	0
Pb mg/l	0.54 (0.13 - 1)	0.19 (0.17 - 0.2)	1 (1 - 1)	0.08 (0.08 - 0.08)	0.01	0.015	0.01
O&G mg/l	0.43 (0.1 - 1.1)	0.53 (0.3 - 1.2)	1.08 (0.5 - 1.5)	1.03 (0.3 - 1.4)	5		

Key- GW- groundwater; SW- surface water; WHO- World Health Organization Guidelines on Drinking Water Quality; US EPA- United States Environmental Protection Agency-National Drinking Water Regulations; NIG. GOVT- Nigerian Government Standards on Drinking Water Quality

(a) pH. The results showed mean pH values slightly below the limits of World Health Organization (WHO) Guidelines and the Nigerian Standards in groundwater samples. The values were 6.44 and 5.93 (Table.3.1). The pH values in surface water sampling points were, however, within the range of limits. They were 6.8 and 7 (Table 3.1). The results of Pilot study 2 showed similar trend. Groundwater sampling points have mean pH values ranging from 5.5 to 5.75 (Table 3.2) showing high degree of acidity in some sampling points to values in moderate range in others. The mean values of pH in surface water sampling points range from 6.44 to 6.7 which were within the range of limits (Table 3.3). All the sampling points recorded high temperatures which were the ambient temperatures. In the Pilot study 1 the values were 26.76 ^{0}C and 27.43 ^{0}C in groundwater sampling points and 27.25^{0}C and 26.55 ^{0}C (Table 3.1) in surface water sampling points. In the Pilot 2 study the temperatures ranged from 25^{0}C to 27.08 ^{0}C (Table 3.2) in groundwater and 26.71 ^{0}C to 29.81 ^{0}C (Table.3.3) in surface water sampling points.

(b) Temperature ^{0} C. The relationship between temperature and pH showed that with increase in the former the value of the latter decreased slightly. High temperatures were due to the rainy season with intermittent high intensity of solar radiation (Kemdirim, 2005).

(c) Electrical conductivity (EC, µS/cm). Mean electrical conductivity (EC) values showed values higher than the limits of World Health Organization (WHO) Guidelines but lower than those of Nigerian Standards (524.29 and 542.36 µS/cm, Table 3.1) in groundwater sampling points. These high values may be due to the dissolution of rock minerals and the presence of salts. The values in surface water sampling points hovered around WHO Guidelines. They were 307.13 and 224.38 µS/cm (Table 3.1.). The low levels of EC in surface water may be due to continuous flow of water which constantly carries away ions and salts. The high EC values in groundwater sampling points may be attributed to the acidic nature since they also have low pH values. It may also be due to the presence of salts.

(d) Total Dissolved Solids (TDS, mg/l). The total dissolved solids (TDS) mean values were 379.14 and 361.86 mg/l groundwater sampling points and 243.75 and 123.32 mg/l in surface water sampling points (Table 3.1). These were all below the limits of WHO Guidelines, U.S. EPA maximum contaminant levels and Nigerian Standards.

(e) Dissolved Oxygen (DO, mg/l). The levels of dissolved oxygen (DO) were below the limits of WHO Guidelines in all sampling points. In groundwater sampling points the mean values were 2.82 and 2.87 mg/l and 2.47 and 2.78 mg/l (Table 3.1). Dissolved oxygen depletion was caused by the combination of factors such as flooding and effluent discharges from domestic and industrial areas. These values are significantly lower than those reported by Kemdirim, (2005) in some parts of the study area. They, however, agree with the work of Xu et al., 2009. The levels also agree with work in SW Nigeria (Adekunle et al., 2007).

(f) Biochemical oxygen demand (BOD, mg/l). The biochemical oxygen demand (BOD) levels somewhat mitigated the dissolved oxygen low levels. BOD levels were found to be below the WHO Guidelines in some groundwater sampling points. The values were 29.21 and 18.28 mg/l which hovered around WHO limit. The levels were, however, high in surface water with mean values of 173.68 and 156.48 mg/l,(Table 3.1) well above the limits. The levels of BOD are similar to those reported by Omo- Irabor et al., 2008) caused principally by industrial, domestic and agricultural effluents.

(g) Total coliforms (cfu/ml) and thermotolerant coliforms (cfu/100 ml). The results showed serious microbiological contamination in all the sampling points. The levels of total and thermotolerant coliforms were above the limits of WHO Guidelines, U.S. EPA and Nigerian Standards. The mean values of total coliforms were 48.57and 65.57 cfu/ml (Table.3.1) in groundwater and 77.75 and 86.75 cfu/ml (Table.3.1) in surface water sampling points. The values of thermotolerant coliforms were 14.57 and 33.57 cfu/100ml (Table.3.1) in groundwater and 11.25 and 21.25 cfu/100ml in surface water (Table 3.1). High levels of coliforms above the limits agree with findings on in rural settlement in SW Nigeria (Adekunle et al., 2007) and from oil producing community in Nigeria (Ejechi et al., 2007).
The probable sources of coliforms in groundwater would be the improper handling of wastes from domestic and agricultural areas which ultimately affected surface water through dumping into water courses through the groundwater/ surface water interactions (Masamba & Mazvimavi, 2008); poor sanitary condition of wells (Machiwa, 1992 and Bordalo and Savva- Bordalo, 2007).

(h) Lead (Pb, mg/l). Pb was detected in all sampling points above the limits of the regulatory bodies. The mean values were 0.54 and 0.19 mg/l (Table.3.1) in groundwater and 1 and 0.08 mg/l (Table.3.1) in surface water sampling points. The probable causes of Pb in groundwater would be the dissolution of rock minerals. In surface water it may be due to the use of leaded petrol particularly in refinery and industrial areas. To corroborate this work, high levels of Pb were reported in ‘contiguous host’ communities of Warri Refinery, Niger Delta, Nigeria (Nduka and Orisakwe, 2009).

(j) Oil and Grease (O&G, mg/l). This was detected in all sampling points. The levels were, however, below WHO Guidelines limit. The mean values were 0.43 and 0.53 in groundwater and 1.08 and 1.03 mg/l (Table.3.1) in surface water sampling points. These levels are significantly lower than those reported from the effluents from Bodija abattoir, Ibadan, (Osibanjo and Adie, 2007) and at Afa canal, Lagos, Nigeria, (Olowu et al., 2010). The inability to record significant quantities of oil and grease in surface water even in refinery and industrial areas may be attributed to adsorption onto sediments since the water bodies appeared oily and were also seen adhering onto the walls of the dug wells.

V. CONCLUSION

In the study, the results showed that the values of electrical conductivity, total dissolved solids, coliforms and lead to be generally above the limits of the regulatory bodies. The results also revealed very low levels of dissolved oxygen. Overall the results showed water contamination regarding dissolved oxygen and microbiological parameters in all sampling points. In the follow-up study the results showed the levels of trace elements to be generally below the limits in all sampling points. Also, the results show that domestic and industrial areas and areas devoted to irrigation activities were found to be most contaminated. In addition to the above refinery area was also found to have contaminated water sources. Surface water sources have more trace elements while groundwater sources have more physico-chemical parameters in all the study. Tap water sources were found to be the least affected in the study.

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