UJPICR Volume 2 Number 1 :June, 2022
UMYU Journal of Pure and Industrial Chemical Research
Volume 2 No. 1 June, 2022.
ISSN: **2814 – 1628/2814 - 1636**
DOI: https://doi.org/10.55688/ujpicr21.014

ASSESSEMENT OF PHYSICOCHEMICAL PROPERTIES OF SOME BOREHOLES LOCATED NEAR WASTE DUMP SITES IN KATSINA METROPOLIS, NIGERIA

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Abstract:

This study aims to quantify the levels of some physicochemical properties in water samples collected from selected boreholes located near waste dump sites in katsina metropolis. The gross appearance of Physicochemical parameters; pH, Turbidity, Temperature, Electrical Conductivity (EC), Colour, Dissolved oxygen (DO), Acidity, Calcium hardness, Chloride (Cl^-) and Nitrate (NO_3^-) were analyzed using standard analytical techniques. The analysis yielded the following mean values with range: pH (5.90 – 6.91), Turbidity (2.10 – 7.43 NTU), Temperature (33.5 – 34.5 ^oC), Electrical Conductivity (0.11 – 1.38 mS/cm), Dissolved oxygen (3.33 – 6.91 mg/L), Acidity (4.92 – 7.41 mg/L), Calcium hardness (102 – 183 mg/L), Chloride (131 – 230 mg/L) and Nitrate (6.03 – 14.92 mg/L). Most of the physicochemical parameters analyzed were within the acceptable limits stipulated by WHO (World Health Organization) and NSDQW (Nigerian Standard for Drinking Water Quality). Hence the quality of the water samples were found below the tolerable level and fit for drinking and domestic purposes.

Keywords: Physicochemical; ground water; Solid waste; pollution

Introduction

Water is an essential component for life on Earth, which contains minerals extremely important in human nutrition [1]. However, the dramatic increase in population resulted in an enormous consumption of the world's water reserves [2]. Everything is originated from water and everything is dependent on water for them. If the solid waste sites are not managed properly may cause surface water pollution and ground water pollution, also adds to air pollution, soil contamination, odor nuisance, disease causing vector, nuisance etc [3]. The landfills and municipal disposal sites have a greater possibility of ground water pollution around the solid waste disposal sites because, the leachate originates from the decomposition of the organic wastes disposed at these sites and finally percolate into the local aquifers. Such contamination of groundwater resource poses a substantial risk to local resource users and surrounding environment. In rainy season, the water gets mixed into the waste and most of the chemicals and decompositions of materials dissolve in water and starts leaching. This leachate creates the problem of ground water contamination [4].

The quality and accessibility of drinking water is essential in the man's unceasing existence and body functioning [5]. Making a portable water obtainable to the population is necessary to prevent health threats [6]. It has been revealed by [7] that 75% of all the diseases in developing countries are associated with drinking water that is polluted.

Water of good quality should be free from chemical which act together with ground water and alter the pH and other water quality parameters and must be suitable in terms of its physical appearance such as colour, the taste should be acceptable as well as its odour, they should be in accordance with the World Health Organization guidelines on the quality of drinking water as cited by [8]. To realize this, different water sources such as wells, bore holes, ponds and streams require protection against contamination by possible parasites, micro-organisms and harmful chemical substances. Drinking contaminated water that does not meet the portability standards, threaten human health. The water can be detrimental when you have pathogens and chemicals that can be harmful to the body, causing diseases [9]. Thus, regular physico-chemical, evaluation of water source must be carried out to determine or check the effectiveness of drinking water treatment process.

Wastes are generated from human activities and in most cases not properly managed in most Nigerian cities. This leads to low environmental quality which accounts for 25% of all preventable ill health in the world [7]. In most cases, wastes are collected and disposed off in uncontrolled dumpsite sited near residential buildings. These wastes are heaped up and/or burnt, polluting water resources and air [10].

This study was aimed to determine the quality of borehole waters near dump sites in Katsina metropolis in order to evaluate their suitability for drinking and domestic use based on certain physicochemical parameters of interest.

Materials and Methods

Location of Study Area

Katsina is located in Nigeria at 12°59′N 7°36′E. It is a city (formerly a city-state), and a Local Government Area in northern Nigeria, and is the capital of Katsina State. Katsina is located some 260km (160 mi) east of the city of Sokoto, and 135km (84 mi) northwest of Kano, close to the border with Niger. As of 2007, Katsina's estimated population was 459,022. The exact population of Katsina will be found in the incoming 2023 Nigerian Census.. The city is largely Muslim and the population of the city is mainly from the Fulani and Hausa ethnic groups.

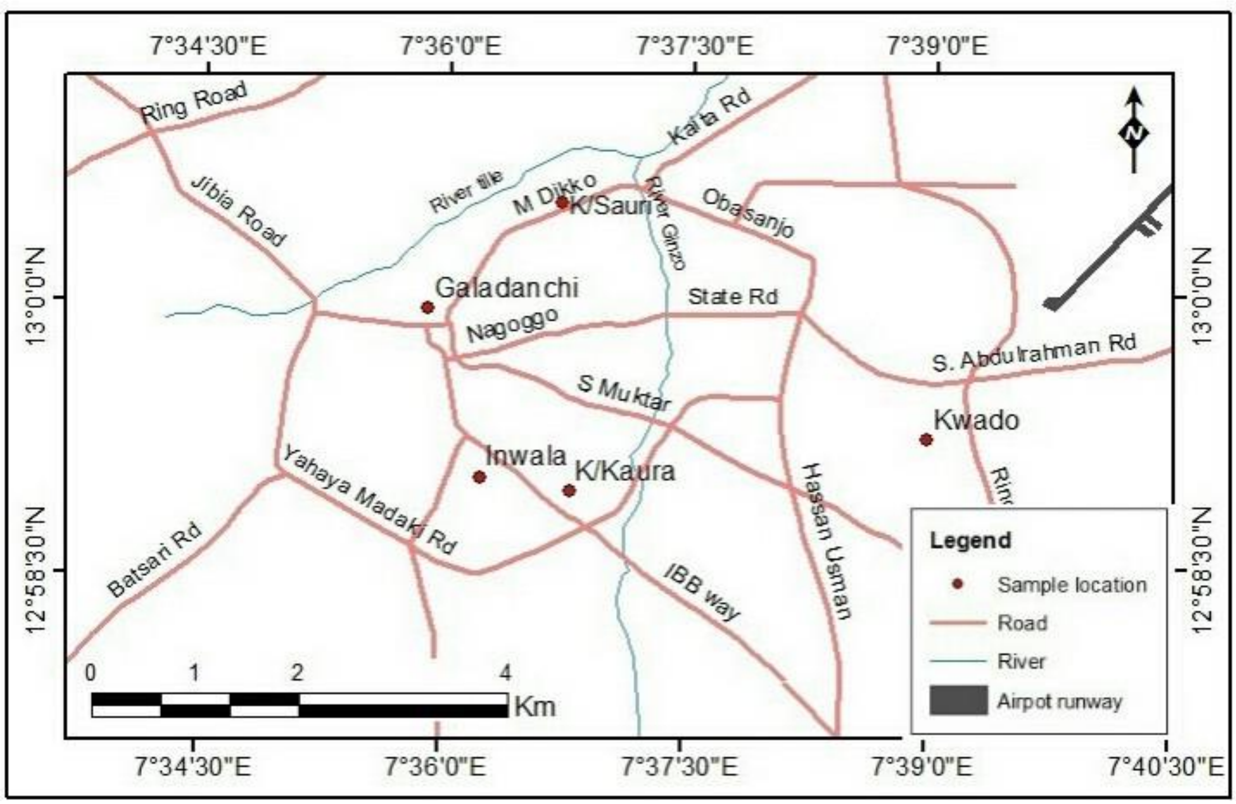

Fig. 1: Map of Katsina metropolis showing sampling locations

Samples Collection

Water samples were collected in a sampling bottle avoiding floating materials. Six samples including control sample were collected around different dump sites in katsina metropolis (Table 1). Controlled water sample was collected from a borehole very far from dump site. The stoppers of the sample containers were closed properly to prevent outside contamination. The containers were labelled describing the date, time and sampling-point. Highly unstable parameters such as pH and temperature were measured at the sampling site to avoid changes in the intrinsic quality of the sample.

Table 1. Sampling Points from Six Locations in Katsina Metropolis.

S/N	SAMPLING POINT	LOCATION
1	GW1	Kwado
2	GW2	Kofar Sauri
3	GW3	Galadinchi
4	GW4	Kofar Kaura
5	GW5	Inwala
6	GW0	G.R.A.

Instruments/Apparatus and Chemical Reagents

Physical tests such as Colour, Turbidity, Temperature and Electrical conductivity were carried out using standard instruments. All chemicals and solvents used were of analytical grades. The glass wares used were washed, rinsed with distilled water and dried in an oven at 110^oC.

Chemical tests

Chemical tests were carried out as per the method described in American Public Health Association [11] and guide manual [12]. pH meter is used to measure the acidity of the different water samples pH meter was rinsed with de-ionised water and dried with soft tissue paper. 100 cm^3 of the sample was measured and placed in a sample bottle after which the electrode was placed in the water sample, and meter reading was recorded. The procedure was repeated for the other samples and the results obtained.

Turbidity was determined using Nephelometer which is calibrated using distilled water (Zero NTU) and a standard turbidity suspension of 40 NTU. The thoroughly shaken sample is taken in the nephelometric tube and the value is recorded.

Temperature measurement is made by taking a portion of the water sample (about

1litre) and immersing the thermometer into it for a sufficient period of time (till the reading stabilizes) and the reading is taken, expressed as °C.

The electrode of the conductivity meter is dipped into the sample, and the readings are noted for stable value of conductivity shown as mS/cm. Colour is determine by measuring about 20 ml of the sample and 20 ml of distilled water were taken in two separate wide mouthed test tubes. The results were tabulated (as clear, greyish, brownish) by comparing the colour of the sample with distilled water.

For Dissolved Oxygen, The samples are collected in BOD bottles, to which 2 ml of manganous sulphate and 2 ml of potassium iodide are added and sealed. This is mixed well and the precipitate allowed to settle down. At this stage 2 ml of conc. sulphuric acid is added, and mixed well until all the precipitate dissolves. 203 ml of the sample is measured into the conical flask and titrated against 0.025 N sodium thiosulphate using starch as an indicator. The end point is the change of colour from blue to colourless [11].

Dissolved Oxygen (as mg/L) = $\frac{(0.2)(1000 \text{ ml of Sodium thiosulphate})}{200}$

Dissolved oxygen Phenolphthalein Acidity: A known volume of sample (50 ml) is taken in a conical flask, to which two drops of phenolphthalein indicator is added and titrated against 0.02 M NaOH. Results are reported in terms of phenolphthalein acidity expressed as $CaCO_3$. This measures the total acidity resulting from both mineral acids and weak acids in the sample [13][14].

Acidity (as mg/L $CaCO_3$) = $\frac{(\text{ml of NaOH used with phenolphthalein})\ (1000)}{\text{mL sample}}$

Calcium Hardness; a known volume (50 ml) of the sample is pipetted into a clean conical flask, to which 1 ml of sodium hydroxide and 1ml of iso-propyl alcohol is added. A pinch of murexide indicator is added to this mixture and titrated against EDTA until the pink color turns purple.

Calcium hardness (mg/L as $CaCO_3$) = $\frac{(T \times 1000 \times 1.05)}{\text{mL sample}}$ Where, T = volume of titrant [11]. Chloride (Cl^-); a known volume of sample (50 ml) is taken in a conical flask, to which about 0.5 ml of potassium chromate indicator is added and titrated against standard silver nitrate till silver dichromate ($AgCrO_4$) starts precipitating [11].

Chloride (Cl^-) = $\frac{(A-B)\ (N)\ (35450)}{mL\ sample}$ Where A = Volume of silver nitrate consumed by the sample, B = Volume of silver nitrate consumed by the blank and N = Normality of silver nitrate.

Nitrates (NO_3^- ; Standard nitrate solution was prepared in the appropriate range: 0, 5, 10, 15, …. 35 mL using distilled water. Each standard have been treated with 1 mL of 1 M HCl. 50 mL of water sample were pipetted into a beaker after filtration, 1 mL of 1 M HCl were added and Mixed well, the sample was transfer to a square UV-Vis cuvette for spectrometry. The absorbance of both samples and standard were measured at two different wavelengths (220nm and 275 nm). For the sample and standards, two times the absorbance reading at 275 nm was subtracted from the reading at 220 nm to obtain the absorption due to NO_3^- [14].

Absorbance due to nitrate = A at 220 nm – (2 x A at 275 nm), where A is the absorbance, Concentration of the standard = mass x absorbance.

Nitrates (as mg/L) = $\frac{\text{Absorbance of sample X Conc.of Std.X 1000}}{\text{Absorbance of Std.X Sample taken}}$

Results and Discussion

The physicochemical parameters of ground water samples near different dump sites at Katsina metropolis were determined and summarized in a table below. Where possible, the values obtained have been compared with the WHO (world health organization) and/or NSDWQ (Nigerian Standard for Drinking Water Quality) guidelines for surface and ground waters [7][15].

Table 2. Mean Physicochemical Parameters of Ground Water Samples Compared with WHO (World Health Organization) and NSDWQ (Nigerian Standard for Drinking Water Quality)

S/N	Parameters	GW1	GW2	GW3	GW4	GW5	GW0	WHO (2004)	NSDWQ (2007)
1	Ph	6.51	6.6	6.91	6.89	5.9	6.98	6.5 – 8.5	6.5 – 8.5
2	Turbidity (NTU)	2.10	4.81	2.80	7.43	6.61	1.22	5	5
3	Temperature (^oC)	33.5	34.0	33.8	34.0	34.5	33.0	Not stated	Not stated

4	Conductivity (mS/cm)	0.11	1.02	0.87	1.38	0.83	0.06	1	1
5	Colour	clear	greyish	clear	brownish	brownish	clear	Not stated	Not stated
6	Dissolved oxygen (mg/L)	3.52	3.33	5.61	4.02	6.91	2.82	Not stated	7.5
7	Acidity (mg/L)	6.63	7.41	7.14	5.98	4.92	4.21	Not stated	Not stated
8	Calcium hardness (mg/L)	112	140	102	183	155	81	75	75
9	Chloride (mg/L)	192	150	206	131	230	47	250	250
10	Nitrate (mg/L)	6.03	14.92	7.78	11.96	6.86	2.37	50	50

pH values ranged from 5.9 to 6.91 pH units (Table 2). This gives the general indication that the water bodies under study ranges from being weakly acidic to neutral. This agrees with the report of [16] and [17]. All the values are at within the permissible level of 6.5 to 8.5 as recommended by WHO and NSDWQ except the value obtained at GW5 which may be due to leachate contamination.

The temperature values of all the water samples analyzed ranged from 33.5 to 34.5^{o}C (Table 2). There was no WHO or NSDWQ guideline value to be compared with. The temperature of water is not the main issue when considering it as physical parameter, but its effect on other properties e.g. changing solubility of gases [4].

Dissolved oxygen is a measure of the oxygen content in water. All the water samples had acceptable dissolved oxygen value for potable water. The dissolved oxygen values of all the water samples analyzed varies between 3.3 to 6.9 mg/L (Table 2). These values were within the NSDWQ guideline limit of 7.5 mg/L specified for drinking and domestic water. This is similar to the findings of [18] and [19].

The colour of ground water samples at GW1 and GW3 were found cleared (i.e colourless), while that of GW4 and GW5 found to be brownish and the sample collected at GW2 were found greyish in colour. The colour perhaps is due to humic substances result from contact with organic debris such as leaves and other leachate contaminants [11].

Conductivity is a valuable indicator of the amount of the materials dissolved in water. The electrical conductivity values for water in the study area varies between 0.11 to 1.38 mS/cm (Table 2). The maximum values were within the WHO guideline limit of 1000 μS/cm (equivalent to 1 mS/cm) stipulated for drinking and domestic water. This is in line with the findings of [16]. The value recorded at GW4 precede WHO and NSDWQ limits, this could be due to the total concentration, mobility and the temperature of the solution of ions [20].

Acidity is a measure of the ability of a given water sample to neutralize strong bases to an indicator end point. The acidity (as $CaCO_3$) values of all the water samples analyzed varies between 4.9 to 7.4 mg/L (Table 2). These values were within the NSDWQ guideline limit of 7.5 mg/L specified for drinking and domestic water. The calcium hardness (as $CaCO_3$) values ranged from 102 to 183 mg/L (Table 2). These values precede the WHO and NSDWQ guideline limit of 75 mg/l stipulated for drinking and domestic water. Hardness is an important criterion for ascertaining the suitability of water for domestic, drinking and many industrial uses [21]. The presence of calcium in water results from passage through or over deposits of limestone, dolomite, gypsum and other calcium bearing rocks.

The Turbidity values of all the water samples analyzed varies between 2.1 to 7.4 NTU (Table 2). The values obtained at GW1, GW2 and GW3 were within the NSDWQ and WHO guideline limit of 5 NTU stipulated for drinking and domestic water. The values obtained at GW4 and GW5 precede the NSDWQ and WHO limits due to the presence of colloidal solids that gives water a cloudy appearance which reduces its transparency. High turbidity of the water samples is due to the infiltration of leachate from the dumpsites into the wells as reported by [22].

The chloride values of all the water samples analyzed varies between 131 to 230 mg/L (Table 2). These values were within the

NSDWQ and WHO guideline limit of 250 mg/L qualified for drinking and domestic water. Chloride content in ground water may result from both natural and anthropogenic sources such as run-off containing salts, the use of inorganic fertilizers, landfill leachate, septic tank effluents, animal feeds, and seawater invasion in coastal areas. Chloride is not harmful to human at low concentration, but could alter the taste of water at concentration above 250 mg/L [23].

The nitrate values of all the water samples analyzed varies between 6.03 to 14.96 mg/L (Table 2). These values were within the NSDWQ and WHO guideline limit of 50 mg/L specified for drinking and domestic water. This agrees with the findings of [19]. The low acidity in the infant's intestine permits the growth of nitrate reducing bacteria that converts the nitrate to nitrite that is then absorbed in the blood stream. The nitrite has a great affinity for hemoglobin than the oxygen and it replaces oxygen in the blood. The deficiency of oxygen causes suffocation. The colour of the skin of the infants becomes blue so it is termed as blue baby disease. This disease is a fatal disease and it takes place when the concentration of nitrates is more than 50 ppm. This indicates that the well water quality in the study area has no potential impact in terms of blue baby syndrome [24].

Recommendations

I recommended that the water quality monitoring should be a continuous process that should be encouraged. Proper sanitation should be strictly observed around the wells and boreholes. Proper and appropriate treatment should be done according to seasonal variation with respect to the important physicochemical parameters. Houses should be situated far away from the landfill site to minimize pollution of nearby borehole waters.

Conclusion

The effect of dumpsite leachate on the physicochemical properties of underground water samples collected from five closest boreholes to municipal waste disposing sites were analyzed. It was suggested that the poor practices of waste management carried out at Municipal Solid Waste Dumping site at Katsina metropolis and the absence of leachate collection system has a great impact on the ground water quality. Most of the physicochemical parameters of the samples were within the acceptable limits of both WHO (World Health Organization) and

NSDQW (Nigerian Standard for Drinking Water Quality). In this research, it was found that the maximum parameters were not at level of pollution. Hence this report explains that the ground water in Katsina metropolis is suitable for drinking and agricultural purposes.

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