Spatiotemporal assessment of effects of leachate from landfills on groundwater in Kano Metropolis, Nigeria

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Abstract. Improper solid waste management in Kano Metropolis, Nigeria has become a serious threat to human health and ground water quality. Groundwater monitoring should be conducted to assess the groundwater contamination, especially originated from leachate generated from the dumpsites. Most of the dumpsites are located nearby water body that subsequently affecting the quality of the water for human purposes. This study aims to investigate the relationships between different physical-chemical and biological parameters during the two seasons (dry and wet seasons) in Kano Metropolis area as well as to identify the sources of variation during the two seasons. The level of some physical-chemical and biological parameters of the groundwater (wells) and dump sites were assessed (i.e. temperature, pH, conductivity, suspended solids, turbidity, hardness, colour, e-coli and coliform). Mean concentration of some physical-chemical and biological parameters except that of temperature, colour, pH and total dissolved solids were found to be above the acceptable limit of the National and International standard of drinking water quality, NESREA and WHO. The sources and variations of the samples results were tested using statistical analysis. The water samples show a considerable level of pollution. The analysis of the groundwater and that of dump sites reveals no significant difference in the parameters measured. It is therefore recommended that the water from this source should be monitored and treated properly before consumption.

Keywords: Groundwater pollution, Water quality, Landfill, Leachate

Track Name: Human, Social, Economic and Environmental Sustainability

1. Introduction

Quality drinking water is vital for life. However, in Nigeria and many other countries around the world still facing an issue with water quality. Quality drinking water has become a scarce commodity as only a small percentage of the general population has access to treated water. Unconventional sources of water such as rainwater and ground water have become major sources of drinking water for people living in new settlements and some residents who do not have access to treated water in Nigeria. The need to assess the quality of water from some of these alternative sources has become necessary because they have a direct effect on the health of individuals. There has been an increase in the growth
of the human population during the past decades in the urban cities of developing countries coupled with an increase in the number of industries and intensive agricultural activities. The increase in waste generation has been linked to the high growth of population, human behaviors and the modern life style. [1][2][3].

Furthermore, the growth and demand for energy, has adversely affected the tributaries of rivers, streams passing through major cities. Moreover, in Nigeria and developing countries more than a billion people lack access to safe water supplies; almost three billion people do not have access to adequate sanitation; five to ten million people die each year from water-related diseases or inadequate sanitation; and twenty percent of the world’s irrigated lands are salt laden, thereby affecting crop production [4].

Poor treatment and inadequate waste disposal from humans, industrial waste and livestock and excessive use of limited water resources, pollutants such as heavy metals, bacteria, viruses and nitrates have infected water supplies. There is potential for natural levels of metals and other chemicals to be harmful to human health even if no sources of anthropogenic contamination existed. It was emphasized in Bangladesh that natural amounts of arsenic in groundwater were discovered to be causing toxic outcomes on the people. Unfortunately, this problem arose because the groundwater was obtained for drinking without a comprehensive water quality investigation.

Higher demand for drinking water in many arid countries which resulted from exponential growing population, primed the need for increased water supply. Many efforts were made to make water available in the area through the construction of wells which supplies water to many people living in the area. For this reason, people in the study area draw their drinking water from untreated surface water bodies like wells. Taking such untreated water directly without treatment may lead to the infestation of water borne disease among the people in the area. This is why it is important to assess the effects of waste dumps on the quality of shallow well water for drinking in the area.

A change in the taste and smell of groundwater are caused by high concentration of chemicals and threatens human health [5]. Consequently, there is a need for the prevention and control of water pollution in order to reduce the scarcity of water resources; it is of immense rational value to study how to remove the unwarranted chemicals pollutants of groundwater. Hence, it is essential to treat and remove hazardous and heavy metals pollution of groundwater using local biomass [6][7].

Water quality tests were conducted by the researchers in many places but most of which are for agricultural uses [8]. Even the ones done on drinking water were in a different environment, the few ones done in the study area were mostly on the chemical parameters of the pipe borne water and borehole water, that is why the same methodology is adopted to assess the physical-chemical and biological parameters of the open well water for drinking in the area in Kano Metropolis, Nigeria. This study also aims to compare the differences in microbial water quality between the dry and wet seasons.

2. Materials and method

2.1 Study area

Figure 1 shows the study area, Tarauni local government area that is located within Kano Metropolis, Nigeria. The metropolitan Kano lies between latitudes of 12°03’N and 8°31’E and longitudes 70°3’N and 1°35’E. The study area is among the seven local government areas that compose the metropolis city which has a lot of infrastructural facilities, utilities and services. It is well accessible from every angle in Kano Metropolis because most of its wards are along Kano-Zaria express way. The local government has ten wards and the area under study lies within the wards.
Figure 1. Study area located in Kano Metropolis, Nigeria.

The climate of the area can be regarded or categorized under AW from Köppens classification. It is also a Sudan savanna climate consists of a cool dry season from October to May, and warm rainy season from June to September. The cultivation period is conventionally during the warm rainy season. The geology of the study area belong to Eutric Gambusol in FOA UNESCO System, with soil taxonomy are moderately deep and well drained with sandy loamy texture most of these soils are underlain by iron pan depth variation between 80 -150 m. The vegetation of the study area is that of Sudan Zone in the West Africa. By cultivation, grazing, cutting and burning, the original natural vegetation of the area has been changed. With increasing setting of people, the original savanna woodland has been altered into degraded savanna in which secondary species are dominant.

2.2 Sampling techniques
To ensure statistical validity of the results, two wells were selected in each of the location of the study area and three dump sites were also selected based on 5 -15 meter radius from the open well in order to assess how much the influence at some interval (Table 1).

The detailed field work was conducted in the following way; direct observation was undertaken at the six selected open wells and three selected dumpsites were visited for identification and collection. The samples collection was done using 2 liter screw-capped bottles that have been purified to prevent cross contamination by any chemical, physical or microbial means. The collected water samples’ temperatures were immediately taken before they were positioned in the ice cooler for conveyance to the laboratory. The water samples were obtained in two different seasons respectively. The seasons are in the months of April, May, and June for the dry seasons and the months of July, August and September for the wet season of the year 2019.
Table 1. Selected wells and dump sites location and distance.

| Samples            | Area                               | Location (Lat, Lon) | Distance from dumpsite (meter) |
|--------------------|------------------------------------|---------------------|--------------------------------|
| Sample 1 (Well water) | Gyadi-Gyadi (Dangi)               | 11°58.644' N, 8°32.405' E | 8 m                             |
| Sample 2 (Well water) |                                    | 11°58.598' N, 8°32.385' E | 13 m                            |
| Sample A (Waste dump) |                                    | 11°58.019' N, 8°32.721' E | 8 m - sample 1 & 12 m - sample 2 |
| Sample 3 (Well water) | Gyadi-Gyadi (Kasuwar Dare)        | 11°58.432' N, 8°32.560' E | 7 m                             |
| Sample 4 (Well water) |                                    | 11°58.439' N, 8°32.602' E | 12 m                            |
| Sample B (Waste dump) |                                    | 11°58.436' N, 8°32.569' E | 5 m to sample 3 & 11 m to sample 4 |
| Sample 5 (Well water) | Gyadi-Gyadi (Babban Layi)         | 11°57.998' N, 8°32.615' E | 8 m                             |
| Sample 6 (Well water) |                                    | 11°58.016' N, 8°32.720' E | 14 m                            |
| Sample C (Waste dump) |                                    | 11°58.128' N, 8°32.598' E | 7 m to sample 5 & 13 m to sample 6 |

2.3 Statistical analysis
To ensure statistical validity of the result, means, standard deviation variance and ANOVA were employed in the analysis of data. The means of physical-chemical and biological parameters in each water sample was compared with national and international standards of drinking water in order to ascertain whether they are within the acceptable limit or not. t-test was also employed to compare the wells water quality.

3. Results and discussion
3.1 Physical-chemical and biological parameters
This section analyses the physical-chemical and biological parameters of the water samples; taking water samples in the dry and wet seasons with the aim of comparing the results with that of national and international standard acceptable limits of drinking water. Table 2 and 3 shows statistical summary of the analysed parameters and their comparisons with the WHO [9] and NSDWQ [10] standards. There were variations in temperature values among the water samples ranging from 26.2 to 31 °C. It was observed that high water temperature improves the growth of microorganisms and may add taste, corrosion, odour, colour, and this value falls within the limit of WHO and FEPA.

During the two seasons (dry and wet), it was noted that all the samples from wells water were marginally coloured which is either by the absorption of light or by coloured substance or due to inappropriate cover on wells. The wells water pH ranges from 6.0 to 8.0 and it remains relatively within the permissible limit. However, it usually has a link with other constituents in water [11]. On its own, however, pH has no direct effect on human or animal health, but because it is so closely associated with other chemical constituents of water, it is often regarded as having an indirect effect on...
health [12]. It is evident that many chemical parameters generating extreme values of pH (i.e. either strong acids or bases) would impact frequently on human health [13].

The range of turbidity is from 0 to 67 NTU and WHO permissible limit is 5 NTU but from the results of the two seasons, it shows that only well 1b (Dangi) during dry season falls above the standard with 67 NTU This shows that there might be a microbial contamination which can cause substantial harm to human. Increased level of turbidity can impart an aesthetically displeasing appearance to water. The materials can also allow adsorption of microorganisms, which protect water from the effects of disinfection and can simulate bacterial growth [14]. Other wells like well 1a (dangi), well 2a (Kasuwar dare), 2b (Kasuwar dare), wells 3a and 3b (Babbanlayi) in the dry season falls below the standard with 0 NTU.

The water samples conductivity ranges from 2.36 to 2770 µs/cm, among all the water samples in the two seasons with most of the values exceeds the maximum permissible limit except well 1a (dangi) in the dry season which is below the maximum limit. The effluent from the different wastes may be responsible for the intensification in the levels. WHO has not set any guideline value for EC in drinking water, it gives an indication about the level of mineralisation of the water source, which often occurs as a result of contamination [15].

The range of the total dissolved solids is from 83 to 1383 mg/L, with all the water samples falls within the acceptable limit except well 2a (Kasuwar dare) in both dry and wet seasons. Since the maximum permissible limit is 500 to 1000 mg/L, therefore the wells with high total dissolved solids will be an obstacle during treatment as it may cause filter clogging.

Hardness is one of the very important properties of ground water, from utility point of view particularly for domestic purpose. From the research results it ranges from 18.81 to 538.704 mg/L, with all the samples analyzed exceeded the maximum permissible limit except well 3a (Babban layi) which is within the permissible range and this may be due to dissolution of polyvalent metallic ions from sedimentary rocks, seepage and run off from soil.

The microbial analysis of the well water samples was carried out. Table 2 and 3 show that only well 1a (Dangi), well 1b (Dangi) and well 2a (Kasuwar dare) water samples met the national and international standard limit. Coliform bacteria must not be detectable in any 100 ml sample of all water meant for drinking. The sources of total and faecal coliform in groundwater may include agricultural runoff, effluent from septic systems or sewage discharge, and infiltration of domestic or wild animal faecal matter; poor well maintenance and construction (particularly shallow dug wells) can also increase the risk of bacteria and other harmful organisms getting into a groundwater supply [16].There is need to have uncontaminated water, since water is necessary to life. By repercussion, the wells around the selected area Gyadi Gyadi are unsafe for drinking, therefore the quality of the water needs to be improved with sufficient treatment in line with microbial standard.

| S/n | Area       | Sample | Month | Parameter      | Temp | pH  | Turb. | EC  | Color | TSS | Hardness | TDS | E.coli | F.coli |
|-----|------------|--------|-------|----------------|------|-----|-------|-----|-------|-----|----------|-----|--------|-------|
| 1.  | Dangi      | 1a     | April | April         | 30.2 | 6.7 | 0     | 2.36| 10    | 3   | 404.028  | 730 | 0       | 32    |
| 2.  | Dangi      | 1b     | April | April         | 30.4 | 6.8 | 67    | 717 | 10    | 5   | 538.704  | 274 | 0       | 10    |
| 3.  | Kasuwar dare | 2a | April | April         | 29.6 | 6.8 | 0     | 1940| 5     | 0   | 471.366  | 732 | 0       | 0     |
| 4.  | Kasuwar dare | 2b | April | April         | 30.2 | 6.9 | 0     | 464 | 10    | 1   | 448.92   | 475 | 51      | 1     |
| 5.  | Babban Layi | 3a     | April | April         | 31.0 | 7.2 | 0     | 840 | 10    | 2   | 448.92   | 658 | 1       | 17    |
| 6.  | Babban Layi | 3b     | April | April         | 29.8 | 7.2 | 0     | 498 | 10    | 0   | 336.69   | 248 | 1       | 15    |
| 7.  | Dangi      | 1a     | May   | May           | 31.2 | 7.23| 2.06  | 2360| 5     | 13  | 279.09   | 1177| 179     | 0     |
| S/n | Area        | Sample Month | Temp. | pH  | Turb. | EC  | Color | TSS  | Hardness | TDS  | E.coli | F.coli |
|-----|-------------|--------------|-------|-----|-------|-----|-------|------|----------|------|--------|--------|
| 1.  | Dangi       | 1a           | July  | 28.7| 7.5   | 4.1 | 340   | 5    | 2        | 350.16| 1168   | 250    |
| 2.  | Dangi       | 1b           | July  | 28.4| 7.4   | 7.0 | 162   | 10   | 1        | 269.35| 809    | 150    |
| 3.  | Kasuwar dare| 2a           | July  | 28.4| 7.6   | 3.2 | 2390  | 5    | 2        | 361.38| 1195   | 80     |
| 4.  | Kasuwar dare| 2b           | July  | 29.2| 7.6   | 6.1 | 1786  | 5    | 8        | 281.31| 893    | 0      |
| 5.  | Babban Layi | 3a           | July  | 28.5| 7.7   | 1.2 | 1043  | 5    | 0        | 202.01| 521    | 75     |
| 6.  | Babban Layi | 3b           | July  | 28.8| 7.6   | 2.13| 1151  | 5    | 1        | 139.17| 576    | 0      |
| 7.  | Dangi       | 1a           | Aug   | 26.2| 6.2   | 4.33| 1813  | 5    | 0        | 435.45| 915    | 230    |
| 8.  | Dangi       | 1b           | Aug   | 25.9| 6.3   | 8.44| 2040  | 5    | 7        | 325.47| 993    | 153    |
| 9.  | Kasuwar dare| 2a           | Aug   | 27.6| 7.6   | 4.38| 1558  | 10   | 1        | 336.69| 781    | 83     |
| 10. | Kasuwar dare| 2b           | Aug   | 27.6| 7.6   | 19.4| 1901  | 10   | 18       | 296.29| 951    | 70     |
| 11. | Babban Layi | 3a           | Aug   | 27.8| 7.7   | 6.6 | 1521  | 5    | 3        | 260.37| 761    | 253    |
| 12. | Babban Layi | 3b           | Aug   | 27.9| 7.6   | 3.2 | 1446  | 5    | 0        | 148.14| 723    | 151    |
| 13. | Dangi       | 1a           | Sept  | 27.3| 7.0   | 1.35| 2770  | 5    | 5        | 480   | 1383   | 0      |
| 14. | Dangi       | 1b           | Sept  | 27.3| 6.8   | 4.73| 1672  | 5    | 12       | 583   | 836    | 0      |

Table 3. Physical-Chemical parameter during wet season.
3.2 Recommendations
With particular reference to the findings of this research, the following recommendations are made:

- Regular monitoring of human activities in the area and public health education on water sanitation is required for all sources of water supply.
- It is recommended that people should device the means of treating water locally to reduce the hazards of biological parameters which are the most dangerous through boiling, addition of alum and local chlorination particularly those suspected to contain high concentration of coliform bacteria, and this should be done by coordination.
- The local communities should be mobilized to undertake regular maintenances and sanitation, and the government should monitor the way and manner waste is being disposed in the area.
- It would also assist in revising current strategies and involvement designed at protecting environment and improving the quality of life within urban and local societies.

4. Conclusions
The study was carried out to assess the effects of waste dump on the quality of well water in Gyadi Gyadi area of Kano Metropolis, Nigeria. The major goal of examining drinking water is to avert the spread of water borne diseases and to safeguard the health of the society. The importance of access to good quality of water cannot be over emphasized. Increase in population in Gyadi Gyadi coupled with the rise in human activity pose a great burden on provision of safe drinking water. This requires large number of people to consume water from shallow open wells which constitute a major health problem in the Gyadi area of Kano Metropolis. This study recorded a high number of coliform counts in water samples analysed, thus making it unsafe for drinking, thus requires further treatment.

This work has revealed that the wells water samples obtained within three locations from six different wells in the dry and wet seasons in the study area did not meet both the national and international standard of drinking water quality and therefore not fit for human consumption.

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