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SPATIAL ASSESSMENT OF GROUNDWATER QUALITY IN PANTEKA MARKET TUDUN NUPAWA, KADUNA, NIGERIA

*[1]Maryam Mustapha, [1]Muhammad Balarabe and [2]Badamasi Ibrahim Bilal

[1]Department of Geography, Kaduna State University, Kaduna, Nigeria
[2]Department Civil Engineering, Airforce Institute of Technology (AFIT), Kaduna, Nigeria

*Corresponding Author Email Address: himammusty@gmail.com

ABSTRACT
Water quality is inherently linked with human health, poverty reduction, gender equality, food security, livelihoods and the preservation of ecosystems, as well as economic growth and social development of our societies. Hence, this research work focuses on Spatial Assessment of Groundwater Quality in Panteka Market Tudun Nupawa, Kaduna, Nigeria. Ten (10) hand dug wells were sample from the study area. The microbial and physico-chemical parameters were analyzed in the laboratory and the data analysis was conducted using SPSS. The results of physiochemical revealed that; Total hardness (TD) ranged between 175-348, Total dissolved Solids (TDS) ranged between 225-645mg/L, Electrical Conductivity (EC) ranged between 451-1,292, Salinity ranged between 29-409. For heavy metals, Lead was higher than the limits given by WHO and Nigerian Standard for Drinking Water Quality (NSDWQ) in 8 sampled wells, and the remaining 2 wells were found 'not detected'. The physicochemical parameters of the samples examined when compared with the WHO standard indicate that some of the parameters are slightly below the WHO standard while others were within the permissible limits of WHO standard for drinking water. The study concluded that water in all the sampled hand-dug wells are not fit for consumption without treatment, because of the deteriorating state of the groundwater in respect to microbiological conditions found. It also recommend that Government should encourage and finance groundwater research by water chemist and scientists to detect areas that can easily pollute groundwater.

Keywords: Groundwater, GPS, Elevation, ArcGIS, DEM.

INTRODUCTION

Groundwater quality is an indispensable factor in consumption of groundwater for agricultural, industrial, domestic and drinking usages (Babiker *et al*, 2007). Groundwater is one of earth's most vital renewable and widely distributed resources as well as an important source of water supply throughout the world. The quality of water is a vital concern for mankind since it is directly linked with human welfare (Balakrishnan *et al*., 2011). Both natural and numerous types of human activities contributed to poor groundwater quality (Varol and Davraz, 2015). Consequently, regular assessment of groundwater parameters is of great significant for sustainable usage of the water around industrial areas. Water quality assessment involves evaluation of the physical, chemical, and biological nature of water in relation to natural quality, human effects, and intended uses, particularly uses which may affect human health and the health of the aquatic system itself (UNESCO/WHO/UNEP, 1996). The use of GIS technology has greatly simplified the assessment of natural resources and environmental concerns, including groundwater.

Groundwater, a valuable resource, is faced with contamination and depletion due to the propagation of civilization and development near water resource (Emenike et al. 2017a, b; Gao et al. 2010; Karkra et al. 2016). Recently, a report published by WHO indicated that groundwater contamination is partly responsible for the death of 1.7 million children below the age of 5 years annually (WHO, 2017). In groundwater studies, GIS is commonly used for site suitability analyses, managing site inventory data, estimation of groundwater vulnerability to contamination, groundwater flow modeling, modeling solute transport and leaching, and integrating groundwater quality assessment models with spatial data to create spatial decision support systems (Engel and Navulur, 1999).
In Nigeria, a large part of drinking water supply is by groundwater through dug wells and boreholes. In many of the rural areas and part of the urban areas too, groundwater is the only source of drinking water; thus, a large population is exposed to risk of consuming contaminated water. Groundwater quality depends not only on natural factors such as aquifer lithology, groundwater velocity, quality of recharge waters and interaction with other types of water or aquifers but also on human activities and the environment. The environment plays an important role in health and human development, and the acute effects from exposure to environmental contaminants are linked to specific environmental hazards with a health effect, such as benzene and leukemia (Temilola and Ismaila, 2011). The rapid pace of industrialization that has nowadays become the need of the hour for a developing country like Nigeria, is a major source of groundwater pollution. The Effluents from industries, domestic sewage, dump sites, fertilizers all contributed to contamination of groundwater by infiltrating into the underground aquifer and pose potential risk to the receptors (Nalbantçılar and Pınarkara, 2015; Rohul-Amin *et al*., 2012). The groundwater aquifer system once contaminated tends to remain for a long period of time, even if the source of pollution, being industrial or domestic wastewater disposal or recycling is eliminated. Shagamu and Otta industrial areas are rated as the fastest growing area in Ogun state. This growth has taken toll on the geological resources in the area and groundwater is primarily one such resource. With the surface water supplies being no longer able to satiate the needs of the residents, groundwater becomes the only alternate source of good quality water. But it is learnt that there are problems aplenty of groundwater contamination in certain parts of the industrial belts Ojekunle *et al*., (2020).
A good number of industries of different types which have been established in the conurbation of Shagamu and Otta have been

loading the environment with ever increasing levels of pollutants which are entering the soil/water and degrading the quality of groundwater seriously. In arid and semi-arid region, groundwater resources have contributed significantly in terms demand for drinking and irrigation due to lack of surface water (Khosravi *et al*., 2016). Groundwater quality is an indispensable factor in consumption of groundwater for agricultural, industrial, domestic and drinking usages (Varol and Davraz, 2015). Both natural and numerous types of human activities contributed to poor groundwater quality (Dairo *et al*., 2019).

Consequently, regular assessment of groundwater parameters is of great significant for sustainable usage of the water around industrial areas. The major industrial activities in the study area that are responsible for water pollution included abattoirs, market, vehicular exhaust, automobile workshops, as well as large volumes of solid waste generated daily and indiscriminately disposed of in the municipality. The health condition of the inhabitants is tied to environmental conditions, sanitation, and surrounding circumstances, but to maintain a healthy living, it is vital to ensure that the quality of water consumed complies with stipulated drinking water standards. Hence, consistent and proper monitoring is necessary (Emenike *et al*., 2018). Unsafe drinking water is of growing concern and has been attracting global attention (WHO and UNICEF, 2014).

A GIS-based study was carried out by Barber et al. (1996) to determine the impact of urbanization on groundwater quality in relation to land use changes. Nas and Berktay (2010) have mapped urban groundwater quality in Koyna, Turkey, using GIS. Balakrishnan et al. (2014) studied Groundwater quality mapping using geographic information system (GIS) in India, where Spatial variations in ground water quality in the corporation area of Gulbarga City located in the northern part of Karnataka State, India, were studied using geographic information system (GIS) technique. GIS provides a platform to effectively handle comprehensive and complicated spatial-temporal information (Imran Ahmad *et al*, 2010; Wieland & Pittore, 2017). Emenike *et al*. (2018), worked on the Assessment of geospatial and hydrochemical interactions of groundwater quality, southwestern Nigeria, where their study revealed that groundwater used for domestic purposes is questionable and therefore calls for scientific scrutiny.

Investigation of hydrochemical interactions and quality of groundwater resource is essential in order to monitor and identify sources of water pollutants. Ojekunle *et al*. (2020) studied the Assessment of physicochemical characteristics of groundwater within selected industrial areas in Ogun State, Nigeria. No study from my literature search has carried out a study of groundwater quality using GIS and remote sensing tools in my chosen area of study. The aim of this study is to carry out the groundwater quality assessment using GIS and Remote sensing tools. GIS software was used to show the spatial distribution of 18 parameters chosen across all 10 locations. Remote sensing data was utilized to create the DEM of the study area which has the potential of showing topography of the study area. DEM will show the possible direction of flow in the area which will aid in the overall discussion of findings.

MATERIALS AND METHODS

Study Area

The study area "Old Panteka Market" is a major mechanical town behind the Sir Kashim Ibrahim Government House inside Kaduna city, Kaduna State, Nigeria. It is incorporated between latitudes 10º0"23'N -10º0"43'N and longitude 7º0"17'E -7º03"7'E. The land mass area has a spatial extent of approximately 3.14km. The landuse/landcover was characterized by a mixture of built-up, vegetation, and bare land. The built-up zone establish an exceedingly popularized region, with a lot of exercises running from business sectors to parks, mechanical workshops, iron drinking sprees etc. The developed region likewise establishes neighborhoods that are firmly stuffed to the business exercises going in the zone. Figure 1.1 below show the landuse map of the study area, which constitutes built-up areas, vegetation and bare land. while Table 2 shows the accuracy assessment of each class.

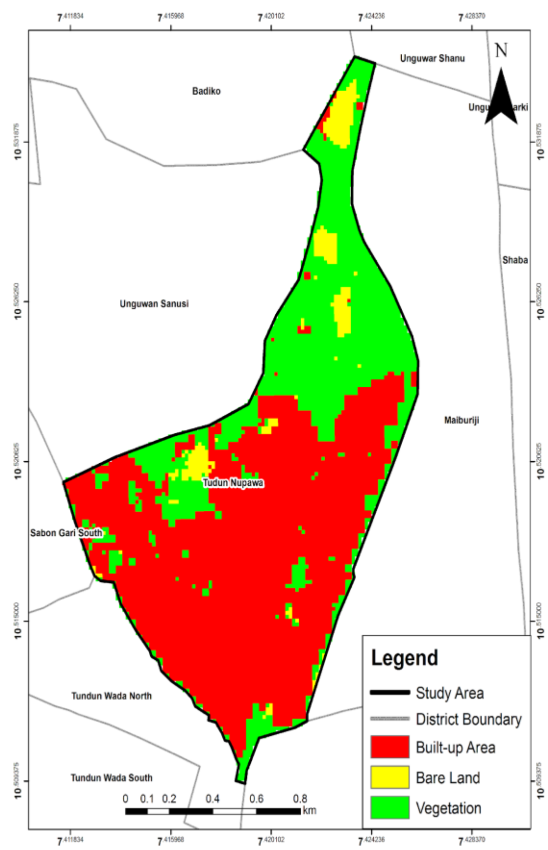

Figure 1: Landuse Map of Study Area
Source; Author's Analysis (2018).

Table 1: Class Statistics

Class	Km2	%
Built-up Area	1.0976	61.90
Bare Land	0.0736	4.15
Vegetation	0.6019	33.95
	1.7731	100

Table 1 shows the class statistics of the three classes on the land use map of the study area,

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Table 2: Accuracy Assessment

Class	Prod. Acc. (Percent)	User Acc. (Percent)
Built-up Area	97.75	100
Bare Land	100	97.73
Vegetation	99.34	89.35
Overall Accuracy	98.09%	
Kappa Coefficient	0.9439	

Sample Collection

Samples were collected from randomly selected ten hand dug wells in the study area, with their locations taken down in the GPS. Water from the wells were drawn by hand and transferred into small plastic water containers that have been sterilized to avoid contamination by any physical, chemical or microbial means and then taken to the laboratory immediately. Figure 3 shows geographic locations of the 10 samples collected in the study area.

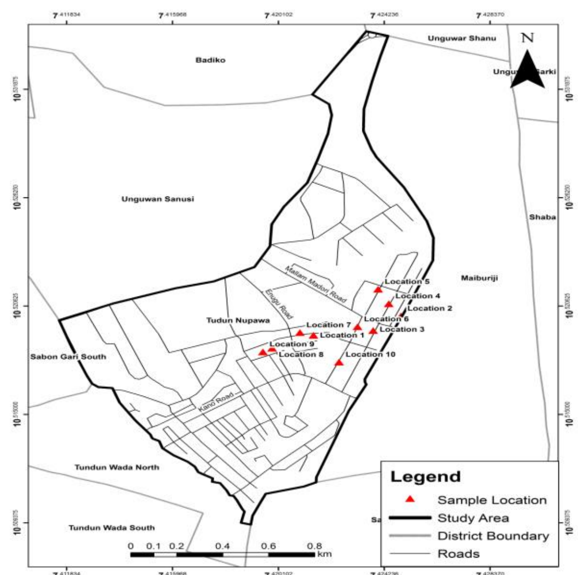

Figure 3: Sample points
Source; Analysis (2018).

Global Positioning System (GPS)

A hand held Global Positioning System (GPS) device (GARMINs Etrex 10 with an error accuracy ±24feet) was used to locate the position of all sampled location during sample collection. The Geographic coordinates (Longitude and latitude) were taken down which was used to show the spatial relation of all 10 sampled locations. The date was then used on the ARCGIS software to show the spatial relationship of sampled location on the map of the study area. Elevation of the area also gotten with the use of the GPS device was used to plot the Digital Elevation Model (DEM) of the study area in other to show the topography, slope and predict the movement of water in the study area.

Method of Sample Collection

Samples were collected in the study area from ten hand dug wells in Panteka in Tudun Nupawa. Water was drawn by hand using rubber buckets/containers and poured into the sample bottles, the sample bottles were rinsed thrice with the well water, before taking the sample into the bottles. 1litre bottle was used to collect samples for physical and chemical parameters, while a water bottle of 250ml was used to collect samples for microbiological parameters. Proper precaution were taken during handling of sampling, by making sure fingertips did not come in contact with the cover of the water samples, in order not contaminate the water bottles and the sample. samples for physiochemical parameters were filled to the brim, while samples for microbiological was filled to 8.5 of the bottle, in order to not suffocate the microbial organisms. A GPS was used to get the location of the all ten locations.

Figure 4; Garmin G.P.S
Source; Author's fieldtrip

Laboratory Analysis

Water samples for the study were analyzed in two laboratories, National Water Resources Institute (NWRI) Mando Kaduna, and Nigerian Geological Research Laboratory (NGRL) Barnawa, Kaduna.

Physicochemical and Microbial Analysis of the Water Samples

Physio Chemical and Microbiological Analysis

The American Public Health Association (APHA) analytical

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methods for the examination of water was used to determine the physicochemical and microbiological parameters of the waters samples. In order to prevent natural interference and unnecessary reactions, analyses of the pH and Electrical conductivity were done immediately after samples were taken to the Laboratory, while others were determined at a later time in the laboratory. Nine water quality parameters were chosen which represent some of the important water quality parameters and also among some of the parameters that contribute to groundwater contamination.

Table 3: Physiochemical and microbiological Composition Standard.

S/N	PARAMETERS	UNITS	WHO GUIDELINES	NSDWQ LIMIT
1	pH		6.5 - 8.5	6.5 - 8.5
2	Electrical Conductivity	µS/cm	1000	1000
3	TDS	Mg/L	500	500
4	Salinity	Mg/L	200	200
5	Turbidity	NTU	5	5
6	Total Hardness	Mg/L	150	500
7	Total Alkalinity	Mg/L	_	500
8	Total Coliform	cfu/100 ml	10	0
9	Fecal Coliform	cfu/100 ml	10	0

Source: World Health Organization (WHO) (2012) and, Nigerian Standard for Drinking Water Quality, NSDWQ (2007). Nephelometric Turbidity Units, NTU, Total Dissolved Solids, TDS.

Table 4: Methods And Instruments Of Laboratory Analysis

S/N	PARAMETERS	INSTRUMENT	METHODS (APHA 2005)	LABORATORIES
1	Electrical Conductivity	Electrometric using wagtech WE30120	APHA 2510B	NWRI
2	Total Dissolved Solids	Electrometric using wagtech WE30120 TDS meter	APHA 2510B	NWRI
3	Total Hardness	EDTA complexometric Titration	APHA 2340C	NWRI
4	Total Alkalinity	PH titrimetric	APHA 2320B	NWRI
5	Total Coliform	Membrane filter	APHA 9222 (membrane filtration	NWRI
6	Fecal Coliform	Membrane filter	APHA 9222 (membrane filtration	NWRI
7	PH	Hanna microprocessor PH meter		NWRI

Source: APHA (2005)
APHA; American Public Health Association.
NGRL; Nigerian Geological Research Laboratory.
NWRI; National water Resource Institute.

Digital Elevation Model (DEM)
Digital elevation model of the study area was created with the use of elevation taken from the locations, with the use of a GPS device. The DEM will show the topography and slope of the study area. Digital Elevation Models are always important for spatial analysis. A DEM can be spoken to as a raster (a lattice of squares, otherwise called a stature map when speaking to height) or as a vector-based triangular sporadic system (TIN). The TIN DEM dataset is likewise alluded to as an essential (estimated) DEM, while the Raster DEM is alluded to as an auxiliary (processed) DEM (Toppe, 1987). The DEM could be obtained through procedures, for example, photogrammetry, lidar, IfSAR, land looking over, and so forth. (Li et al., 2005). DEMs are ordinarily manufactured utilizing information gathered utilizing remote detecting systems, however they may likewise be worked from land looking over.

RESULTS AND DISCUSSION
This section shows the result of the data input into the GIS software for the spatial location of all 10 sampled locations and the Digital Elevation model of the study area. This section also shows the spatial distribution of the measured parameters for the study.

Digital Elevation Model (DEM)
The DEM was used to extract the slope, topography and flow accumulation of the study area using ArcGIS software. Digital elevation model can be used in the determination of direction of water flow, as well as watershed delineation. The elevation of the area as shown in decreases from north to south, indicating that the groundwater flow in the area is from north to south. The elevation values in the area ranged from 519 to 603m.

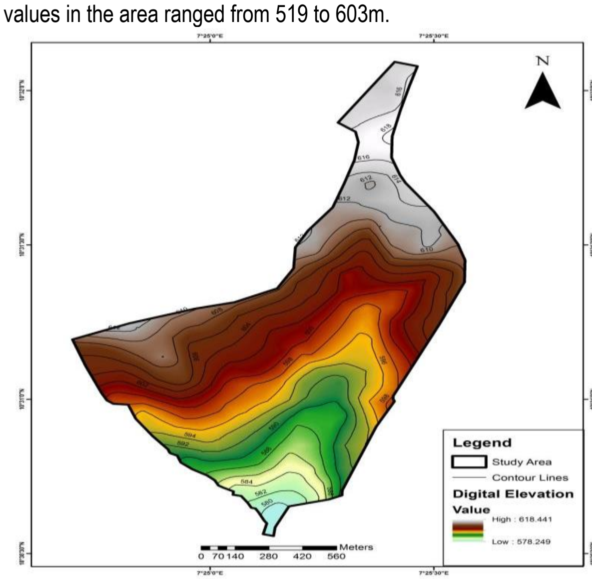

Figure 5: DEM of The Study Area.
Source: Field Work, (2018).

Results of Physio-Chemical Analysis
This section discusses the results of the analysis of all nine measured parameters which were spatially distributed in the study area.

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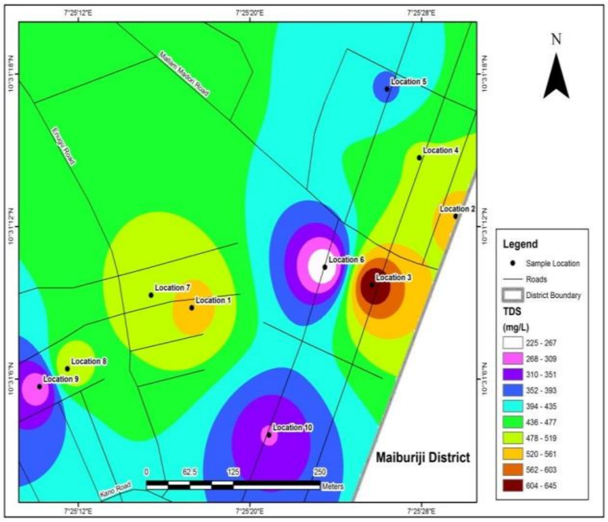

Figure 6:Spatial Distribution Of Total Dissolved Solid.
Source; Field Work, (2018)

Total Dissolved Solids
(Jimmy *et al*., 2012) the authors explained in their study on how TDS is found in different water bodies, they explained it as an inorganic substance that find its way into either subsurface or surface water bodies. The presence of these unwanted substances could be due to natural forces or nature of the environment. The introduction of unnatural substance into body of water may lead to the water generating an unnatural taste (WHO 2006). It is important for there to be a balance in the amount of TDS found in water, because having TDS of very low rate could also lead to an unfamiliar taste in water (Isa, *et. al.,* 2003) and (WHO 2006). Total dissolved solid (TDS) most times contains salt of inorganic origins which could include of the following elements; calcium, magnesium, potassium, sodium, bicarbonate etc. and small amounts of organic matter that are dissolved in water (W.H.O,2011). From table 3 which indicated acceptable limit for each parameter, the acceptable limit given by WHO is 500 mg/L. Figure 6 shows the spatial distribution of TDS in the study area which shows four locations having TDS values above acceptable limits given by both WHO and NSDWQ.

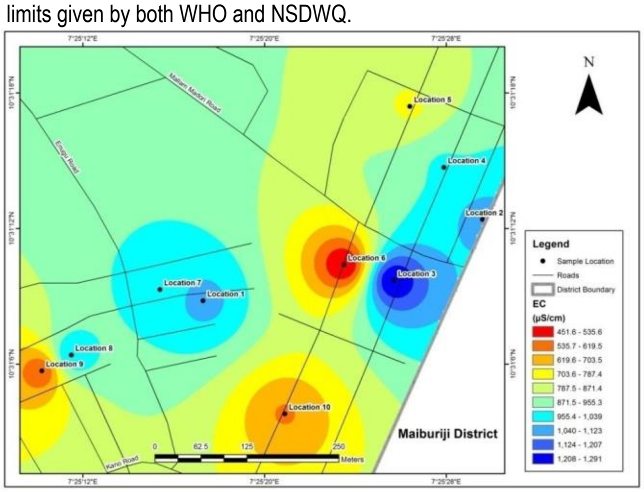

Figure 7: Spatial Distribution Of Electrical Conductivity(EC)
Source; Field Work, (2018).

Electrical Conductivity
Higher estimation of conductivity is a decent marker of the nearness of contaminants, for example, sodium, potassium, chloride or sulfate (Orebiyi et al., 2010). Very high electrical conductivity can lead physiologically dry spell in plants. The acceptable WHO MPL(2012) and NSDWQ Limit (2007) is 1000 µS/cm. Figure 5 shows the spatial distribution of EC in the study area which shows four locations having higher values of EC which is found to be above acceptable limits given by WHO and NSDWQ. Considering EC most of the water in the study area will need to be treated before consumption.

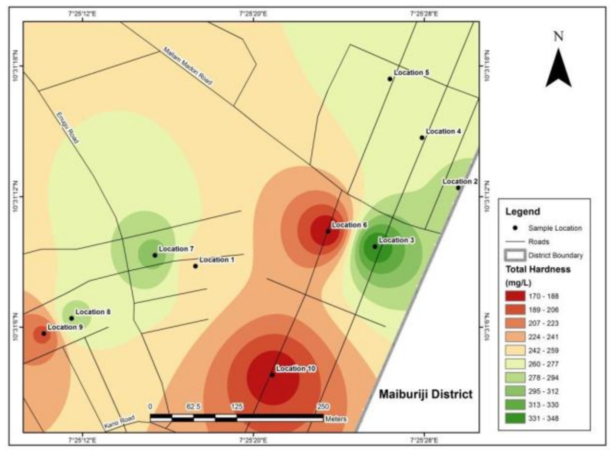

Figure 8:Spatial Distribution Of Total Hardness
Source; Field Work, (2018).

Total Hardness
Calcium and magnesium mostly cause the hardness of water. The total hardness of water may be divided in to 2 types, carbonate or temporary and bi-carbonate or permanent hardness. The hardness produced by the bi-carbonates of calcium and magnesium can be virtually removed by boiling the water and is called temporary hardness. The hardness caused mainly by the sulphates and chlorates of calcium and magnesium cannot be removed by boiling and is called permanent hardness. Total hardness is the sum of the temporary and permanent hardness. Water that has a hardness of less than 75 mg/L is considered soft. A hardness of 75 to 150 mg/L is not objectionable for most purposes. Water having more than 150 mg/L hardness, is unsafe. The removal of temporary hardness by heat causes the deposition of calcium and magnesium carbonates as a hard scale in kettles, cooking utensils, heating coils, and boiler tubes resulting in a waste of fuel (Balakrishnan *et al*., 2011). Distribution of Total hardness in figure 9 shows a result of total hardness from 170-348 , the total hardness from all the samples were all within the MPL given by WHO of 500mg/L, while all samples were above the limit given by NSDWQ guidelines. Groundwater exceeding the limit of 300 mg/L is considered to be very hard (Sawyer and McCarty, 1967). This excess according to(Appello and Postma 2005) causes cataract, diuretics disease and diarrhea in man and scouring disease among livestock.

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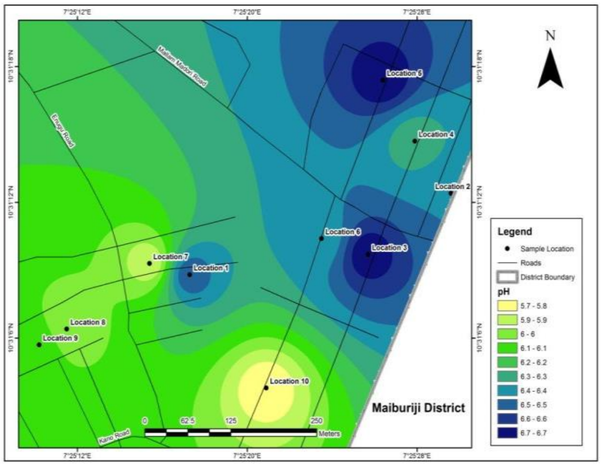

Figure 9:Spatial Distribution Of PH
Source: Field Work, (2018).

pH
As indicated by Fakayode (2005), the pH of a water body is significant in the assurance of water quality since it influences other compound responses, for example, dissolvability and metal harmfulness. pH of groundwater has no immediate wellbeing suggestion on people however marginally acidic PH worth can disintegrate overwhelming metals from well siphons and pipes framework (Anudu *et al*, 2011). Substantial metal, for example, Lead, Zinc and Copper are ordinarily used in channels and fittings are cancer-causing when ingested over some undefined time frame (Hem, 1991).The WHO and NSDWQ recommended guideline value for drinking water is 6.5-8.5. Spatial distribution of PH shown in figure 10, pH of water samples from the study area observed was between 5.7-6.7. the result revealed that most of the groundwater sampled in the study area were found to have values below acceptable limits given by both WHO and NSDWQ. The result shows that the groundwater should be treated in order to be most suitable for consumption.

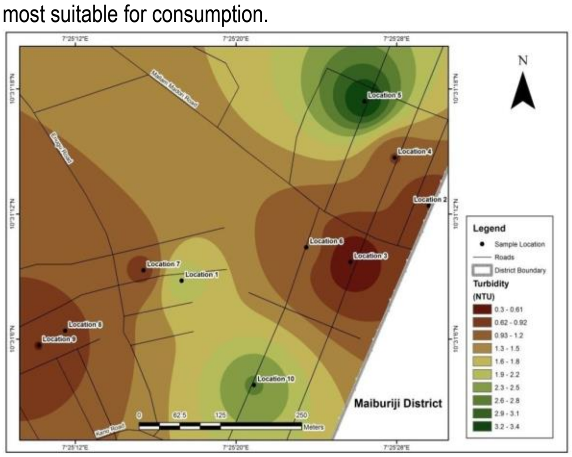

Figure 10:Spatial distribution of Turbidity
Source; Field Work, (2018).

Turbidity
Turbidity, which is the optical trademark or property of a fluid, for the most part depicts the clearness or cloudiness of the fluid. It can likewise be portrayed as the measure of suspended materials (earth, sediment, green growth, among others) in water Ponce, V. M. (2014). Solids found in water can be broken down, suspended, unpredictable or fixed. They incorporate residue particles, and every other segment that structure the undissolved bit of water or can shape a buildup in the wake of drying. The WHO and NSDWQ maximum allowable concentration is 5(NTU). Distribution of parameters in figure 7 shows the value of tested turbidity from samples analyzed in the laboratory which revealed that all samples were not found to be over the limits given by WHO and NSDWQ.

Salinity
The nearness of a high salt substance may render a water inadmissible for household, rural or mechanical use, or may influence its appropriateness Saltiness is a proportion of the salt substance of water. At the point when an individual devour water with high measure of saltiness past the most extreme admissible breaking point of WHO and other applicable offices, such individual might be inclined to hypertension. Beside human inebriation, it might influence the disintegrated oxygen level of water as new water holds more oxygen than salt water (Chinedu et al 2011). The nearness of a high salt substance may render a water inadmissible for household, rural or mechanical use, or may influence its appropriateness (Olobaniyi and Owoyemi, 2006).The acceptable limit for salinity given by WHO and NSDWQ IS 200mg/L. Spatial distribution of salinity in the study area shown in figure 8 shows the value of salinity ranges from 29.2-409mg/L, which further revealed that four locations had salinity values above the acceptable guideline. This result indicates that some of the groundwater in the area will require some treatment before usage.

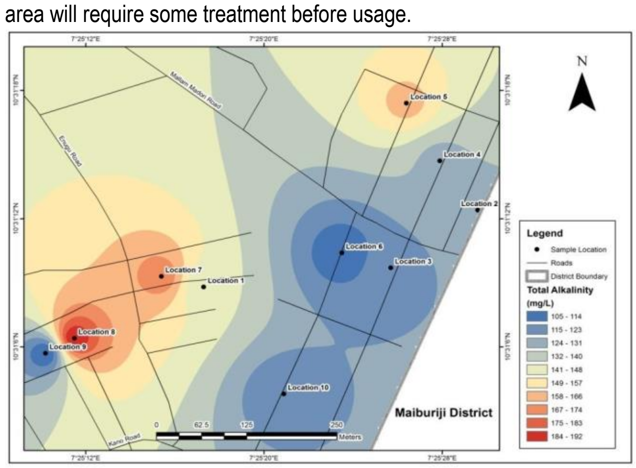

Figure 11:Spatial Distribution Of Total Alkalinity
Source; Field Work, (2018).

Total Alkalinity
Water alkalinity and hardness are functions of the geology of the area and the percolation of rain and surface water along with the dissolved carbon dioxide of the atmosphere. Rain water is naturally acidic, which tends to dissolve some minerals more easily (Arabi *et al*., 2011). Excess alkalinity results to a distinct flat and unpleasant taste, and also scale formation. (Orewole *et al*., 2007). The result gotten from all 10 hand dug wells were all within the MPL given by (WHO) of 500mg/L. Distribution of Total alkalinity in the study area shown in figure 4 shows total alkalinity to be within acceptable limits.

Results of Microbiological Analysis

This section discusses Microbiological analysis with the parameters spatially distributed in the study area.

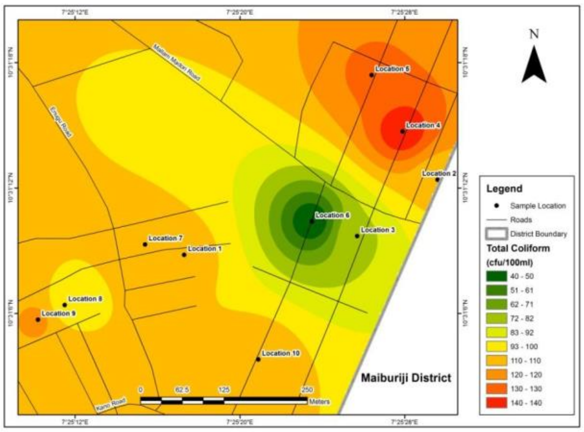

Figure 12:Spatial Distribution Of Total Coliform
Source: Field Work, (2018).

Total Coliform

The total coliform counts of all the water samples were generally high. They exceeded the standard requirement of 10 total coliform counts per 100 ml for NSDWQ and zero total coliform count per 100 ml for WHO (Table 3) . The implication of this finding is that water from these wells may look clean to naked eye and have no unwanted odour or taste but contains pathogenic bacteria that can cause significant illness such as gastrointestinal, urinary tract infection (UTI) tract infections, which may even become fatal in severe condition (Allamin *et al*, 2015). The results of this study correlate with the report of Bello *et al* (2013) and Allamin *et al* (2015) who showed that the water samples from well was highly contaminated with coliform bacteria.). The total coliform count analysed were all above the accepted limits given by WHO and NSDWQ. Spatial distribution of Total coliform shown in figure 11 shows that the range of Total Coliform was found between 40-144. This result reveals an overall contamination with respect to total coliform, hence the need for proper treatment before consumption.

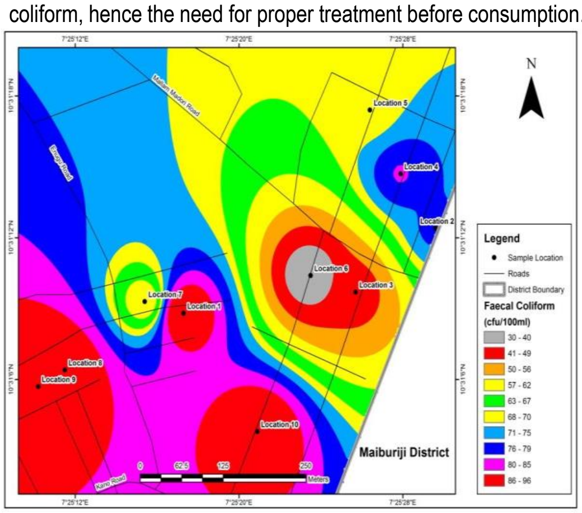

Figure 13:Spatial Distribution Of Fecal Coliform
Source; Field Work, (2018).

Fecal Coliform

The presence of coliforms in these water samples generally suggests that a certain selection of water may have been contaminated with faeces either of human or animal origin (Okonko *et al*., 2008).This could be due to the close proximity of toilets to the hand dug wells in the study area, it could also be attributed to the location of soak ways in the houses which could seep into the hand dug wells.). The fecal coliform count analysed were all above the accepted limits given by WHO and NSDWQ (Table 3). The range of Fecal Coliform as shown on the spatial distribution of fecal coliform in the study area in figure 12 was found between 30-96.

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