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Effect of Waste Dumpsites on Groundwater Quality in Samaru Area of Zaria Kaduna State

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ABSTRACT
This study investigated the effects of waste dumpsites on groundwater quality at Samaru-Zaria, Kaduna State. Water samples were collected from twenty-four (24) different wells from three (3) strategic areas that have major waste dumpsites in Samaru. Twelve of these samples were taken during the dry season (April) and another twelve taken during the rainy season (August) from both boreholes and hand dug wells. Out of the twelve samples, six were taken within (0-50 meters) to dumpsites and another six far away (50-150 meters) from the dumpsite. The pollutants assessed include, Biological Oxygen Demand, Total Dissolved Solids, Dissolved Oxygen, Chemical Oxygen Demand, Chloride, Total Hardness, Colour, pH. T-test was used to test for significant difference between parameters while chi-square was used to test for the relationship between quality of water in wells close to and those far away from waste dumpsite in dry and rainy season. From the findings of the research it was discovered that many wells in the study area located close to the dumpsite (0-50 meters) have levels of concentration of pollutants of physico-chemical to be high (in wells close to dumpsites) compared to wells far from dumpsites 50-150 meters. It was also discovered that the concentration of pollutants during the wet season is higher than that during the dry season. From laboratory analysis conducted it was discovered that COD had the highest physico-chemical concentration of 648.50mg/l and BOD a concentration of 1.70mg/l. It was also discovered that deep and shallow wells close to dumpsites have a higher total contamination rate than deep and shallow wells far from dumpsites but there was no significant difference between them as revealed by the t-test. Thus, such water should be treated by employing some measures such as the use of disinfectants or boiling before use which will help reduce the pollutants.

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INTRODUCTION

The sustenance of life depends greatly on water, therefore, the demand for potable water increases continually in line with world population growth. Recently, many African cities have undergone unprecedented growth in population through migration from rural areas which has led to the growth of cities into sprawling "mega-cities" with large areas of unplanned sub-standard housing with few services. The unplanned expansion of such cities leads to a serious pollution threat to the groundwater and uncontrolled industrial and commercial activity add to the pollution threat (UNEP, 2002). This has been a major problem in developing countries; provision of drinking water has become expensive and difficult. The main source of potable water in many of these cities is groundwater, commonly from shallow hand-dug wells and deeper water supply boreholes. In Nigeria, like many other developing countries, open waste dumping system has been the major management option of solid waste disposal. In previous years, management system has been based on

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collection and dumping out of the city boundaries in conformity with the concept of "out of sight out of mind" (Arukwe et al, 2012). But in recent times, the siting and development of residential quarters near waste sites are common due to shortage of building land to cope with the increasing rate of migration and consequent population explosion (Ikem et al., 2002).

Dumpsites have been identified as one of the major threats to groundwater resources, receiving a mixture of municipal, commercial and mixed industrial wastes. The depressions into which solid wastes are often dumped include valleys and excavations. Studies on the effects of unlined waste dumps on the host soil and underlying shallow aquifers have shown that soil and groundwater system can be polluted due to poorly designed waste disposal facilities (Amadi et al., 2012). Uncontrolled waste dumpsites threaten the groundwater supply as movement of leachates from dumpsites through the soil and the aquifers pose a risk to the environment and human health. Waste placed in dumpsites or open dumps are subjected to groundwater under flow or infiltration from precipitation (Mor et al., 2006). The presence and potential exposures of the community to groundwater contaminants may contribute to the predilection of human health impacts, from simple poisoning to cancer, heart diseases and teratogenic abnormalities.

Release of pollutants through leachates from both functional and abandoned dumpsites pose a high risk to nearby soil and groundwater if not adequately managed (Ikem et al., 2002). Leachate percolating into the groundwater is a mixture of highly complex contaminants such as potentially toxic metals(lead, mercury, cadmium, chromium etc); persistent organic pollutants (POPs) (dioxins, furans, polycyclic aromatic hydrocarbons (PAHs), polybrominated diphenyl ethers PBDEs); inorganic compounds (such as ammonium, sulphates, chlorides) and as well as bacterial contamination – total coliform and faecal coliform (Mor et al., 2006; Longe and Balogun, 2010; Oyeku and Eludoyin, 2010; Galarpe and Parilla, 2012). Therefore, considering possible impact to surrounding environment brought by dumpsites is inevitable.

LITERATURE REVIEW

The physical environment has its waste receiving capacity. That is a threshold, after which hazards occurs. The waste that interferes or defers the waste receiving capacity of the environment creates pollution. The degree of intensity of this interference is growing as our waste load grows (Wesley, 1971). With continuous increase in population, largely due to migration into Samaru, more and more waste products are released into the environment due to increase in consumption levels. Although solid waste is a nuisance, it is possible to extract useful material from them through recycling. Refuse collection and disposal in most urban centers was for a long time a function of the government, and only recently some communities have taken into the business of refuse waste management (Abah and Ohimain, 2010).

The need to protect the environment has compelled the Nigerian government to put in place environmental protection related policies over the years. For instance, the third national development plan of 1975-1980 was made to accommodate environmental protection policy as a vital part of the development plan. This was further re-enforced in the fourth National Development Plan of 1981-1985. This particular plan has a proposal to include the Environmental Impact Statement (EIS). In 1988, the Federal Environmental Protection Agency (FEPA) was established and the national guidelines on pollution control was established and signed into law. In 1992 the Urban and Regional Planning decree was promulgated. Sequel to all these, the Kaduna State Environmental Protection Authority (KEPA) amended its environmental protection edict number 9 of 1994 and charged KEPA with legal responsibility to oversee the State's environment. Because of the importance of keeping our environment clean and the great problem solid waste constitute to the environment, the Kaduna State Government under the leadership of Arch. Namadi Sambo, in 2008 introduced a programme called Operation Keep Kaduna Clean, this was aimed at keeping Kaduna state clean, free from the menace of indiscriminate dumping of waste (Abah and Ohimain, 2010).

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Wastes

Different terminologies have been used in the past to define waste. Different countries pronounced waste in their own terms. It has been known as garbage, refuse, and so on. Vastum, French word meaning empty or desolate, was the first term to define waste. Later, the term waste evolved during late 1770s with the industrialization. At that time, the term waste was used for excreta which had been the main cause of urban pollution and to better manage this waste, it was used as a fertilizer (Barles, 2014). Nelson et al.,(2009) described waste as solid or liquid materials which are discarded as used, useless, worthless or excess items. An example of waste is the excess gas flared due to lack of storage facilities during crude oil exploration.

The United Nations Statistics Division, (2011) see wastes as materials that are prime product for which the generator has no further use in term of his/her own purposes of production, transformation or consumption, and of which he she wants to dispose. Waste is defined as any unwanted material that is due for discarding. But technically, waste is considered as a resource in the wrong place (Abdullahi, 2011). Waste is the useless by product of human activities which physically contains the same substance that are available in the useful product (White et al, 1995). Wastes have also been defined as any product or material which is useless to the producer (Basu, 2009). Dijkema et al, (2000) pointed out that, wastes are materials that people would want to dispose of even when payments are required for their disposal. Although, waste is an essential product of human activities, it is also the result of inefficient production processes whose continuous generation is a loss of vital resources (Cheremisinoff, 2003).

Domestic and municipal solid waste disposal

Solid waste generated by private homes, businesses, industries, and public buildings can be disposed of in the direct vicinity of these places or be collected and deposited at solid waste disposal sites. In many cases, these disposal sites may just be pieces of open land that have been fenced off, excavations and old mining areas, or isolated ravines and valleys. In the case that no proper sanitary measures have been taken at the site, leachate may form and infiltrate into the subsoil. Leachate is the contaminant-loaded liquid that is formed at the base of the disposal site when infiltrating and percolating rainwater is available in sufficient quantity (Mohd, et al., 2011).

Groundwater

Groundwater is a globally important and valuable renewable resource for human life and economic development. It constitutes a major portion of the earth's water circulatory system known as hydrologic cycle and occurs in permeable geologic formations known as aquifers i.e. formations having structure that can store and transmit water at rates fast enough to supply reasonable amounts to wells. The importance of aquifer comes from its ability to act as a large reservoir of water that provides "buffer storage" during periods of drought. In rural context, groundwater provides the mainstay for agricultural irrigation and will be the key to provide additional resources for food security. In urban centers groundwater supplies are important as a source of relatively low cost and generally high quality of municipal water supply (WHO 2004).

The importance of groundwater is gaining recognition, because this resource: represents some 98 percent of the planet's freshwater resources (polar ice excluded), supplies more than 1.5 billion urban dwellers with water, is extensively used for low-cost rural water supply, is increasingly developed for both large- and small-scale irrigation, is generally reliable in periods of drought because of its large storage capacity, is cheap to develop because of its widespread occurrence and its generally good natural quality (Okoye and Nwagbogwu, 2012).

Natural composition of groundwater

The chemical composition of groundwater mainly depends on the composition of the initial pore water; the composition of infiltrating water and subsurface inflow that replaces the pore water; the composition and physical properties of the soil and rock; the chemical interaction between rock, pore water, and infiltrating water; and microbiological processes. From the moment rain falls on the ground and begins to infiltrate and pass through the soil and rock, the water dissolves the host

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materials, and minerals are added to the groundwater flowing through. In general, the amount of Total Dissolved Solids (TDS) increases with the residence time of groundwater (Kofoworola, 2007).

Table 1: Chemical constituents in groundwater

Major constituents	Secondary constituents	Selected minor	Trace constituents
Calcium (Ca)	Potassium (K)	Aluminium (Al)	Molybdenum (Mo)
Magnesium (Mg)	Iron (Fe)	Arsenic (As)	Nickel (Ni)
Sodium (Na)	Manganese (Mn)	Barium (Ba)	Phosphate (PO4)
Bicarbonate (HCO3)	Strontium (Sr)	Cadmium (Cd)	Radium
(Ra) Chloride (Cl^-)	Boron (B)	Chromium (Cr)	Selenium
(Se) Sulfate (SO4)	Fluoride (F)	Cobalt (Co)	Silver (Ag)
Silica (SiO2)	Carbonate (CO3)	Copper (Cu)	Uranium (U)
	Nitrate (NO3)	Lead (Pb)	Zinc (Zn)
		Mercury (Hg)	Sulfide (H2S, HS)

METHODOLOGY

The Study Area

The study was conducted at Samaru New Extension, Danraka and Hayin Dogo all in Samaru.

Location

Samaru is part of the Zaria urban setting. It lies within latitude 11°09'30.99"N and longitude 7°38'15.68 to 7°39'20.68"E at an altitude of 550-700m. Samaru is located at the central high plain of Northern Nigeria at the height of about 670 meters above sea level. Samaru is found in Sabon Gari Local Government Area and it is bounded to the North and North East by

Bassawa military cantonment, to the South by Ahmadu Bello University (ABU) main campus, and to the West by Division of Agricultural Colleges (Fig.1). Samaru is a semi-urban university satellite town blessed with abundant ground and surface water (Yusuf, et al., 2007). In spite of its potentials for good groundwater storage, the poor water distribution and supply have made this community reliant on well water for drinking and other domestic purposes (Musa, et al., 2008).

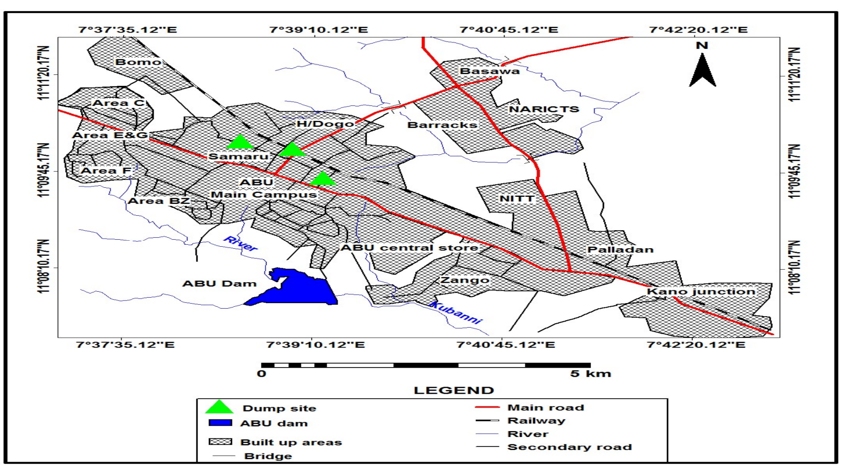

Figure 1: Samaru and its environs showing the selected dumpsites.

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Reconnaissance Survey

As a preparation for the study, a reconnaissance survey was undertaken to properly study the area before starting the full research. The objectives were to obtain available relevant information on the environment of the study area, intimate and seek cooperation of residents residing around the dumpsites and to select the wells that water samples were to be collected from for detailed investigation through laboratory analysis.

Types and Sources of Data

The types of data used for the research work are the physico-chemical properties which are the; Biological Oxygen Demand (BOD), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Chloride (Cl), Total Hardness, Colour and pH. The source of data employed in this research work is basically of two types which are the primary and secondary data sources. The primary data sources were gotten from the field in the form of soil and water samples. While the secondary sources of data were gotten from stored data that have been collected by others such as various levels of government agencies, research institutions.

Sampling Technique

Razaq and Ajayi (2000) define sampling as a systematic process used to select a required portion of a target population or area. In order to achieve a desired output and conduct a thorough study, the researcher used the three major dumpsites in Samaru (Fig.1).

The sampling technique employed for this research is the purposive sampling technique, because sampling site for well water sample collection was purposively chosen. Sample collection was in early April, which is the dry season and August when Samaru receives the highest amount of rainfall. This is so, in order to observe any temporal variation in the well water quality of the study area. The well water samples were taken from distance that range from less than 10 meters (<10m) to distance of greater than 150 meters (>150m) away from the dumpsites (Peter, Paul and Thomas, 1995). However, in a situation where a borehole or hand dug well is not found within the 10m range the well closest within the range of 10-150 meters were used as wells close to the dumpsite and those 150 meters away were used as wells far away from dumpsite for both the borehole and hand dug wells.

A total of twenty-four (24) water samples were collected for the purpose of this research, because twenty-four samples would properly cover the study area and also because of the high cost of water analysis in the laboratory. Out of which twelve (12) were for the first month of sample collection (dry season, April) and another twelve (12) samples for the second month of samples collection (wet season, August). Out of each twelve samples, six (6) water samples were collected from shallow wells of depths of between 10-20 meters and the other six (6) samples from deep wells of depths greater than twenty-five (25) meters and above. Three of the well samples for both hands dug wells and deep were located close to the dumpsites, while the other three were far away from the dumpsites.

RESULTS AND DISCUSSION

Distance of Wells from Dumpsite in the Study Area in Meters

The distance of wells from dumpsite in the study area for both hand dug and boreholes is presented in Table 2. This shows that shallow wells are located closer to dumpsites than the deep wells in Samaru

.**Table 2:** Distance of Wells to Dumpsite in the Study Area (in meters)

	Close to Dumpsite Distance (Meters)		**Far from Dumpsite Distance (Meters)**	
Location	**Hand dug well**	**Borehole**	**Hand dug well**	**Borehole**
Samaru New Extension	7.40	26.50	152.00	160.00
Hayin Dogo	6.90	30.20	170.00	151.00
Danraka	3.00	8.00	150.00	152.00

Source: Field Survey, 2020

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Physico-Chemical Properties of Well water in the Study Area

The water samples collected were twenty-four (24) from different wells, and three soil samples collected from the dumpsites in the study area. The twenty-four water samples were gotten from different sources of both shallow wells (hand dug) and deep (bore hole) wells, at different time frames i.e. Dry (April) and Rain (August) seasons and also from different distances.

The physico- chemical properties of water quality for deep and shallow wells close to and far away from dumpsite for all point selected during dry and rainy season are presented in Table 3 to Table 8. The results shows that for all wells considered pH, Colur, DO BOD and Chloride all fall within the accepted limit for both WHO of 2011 and NSDWQ f 2007 but parameters like TH, TDS and COD mostly are above the acceptable limit stipulated by WHO of 2011 and NSDWQ f 2007.

Table 3: Physico-chemical Properties of Well Water in Samaru New Extension during Dry season (April)

S/N	Parameter Mg/l	Borehole Close to	Borehole Far away	Hand dug well Close to	Hand dug well Far away	WHO (2011) Standard	NSDWQ (2007) Standard
1.	pH (Unit)	6.21	7.30	6.91	7.11	6.5-8.5	6.5-8.0
2.	Colour (Unit)	5.00	5.00	5.00	5.00	5.00	5.00
3.	DO	1.71	1.40	1.50	1.60	3.00	3.00
4.	BOD	0.50	1.30	0.60	0.90	0.8-5.0	0.8-5.0
5.	Chloride	44.30	10.26	66.40	12.49	200.00	200.00
6.	TH	251.40	301.20	646.40	515.10	400.00	400.00
7.	TDS	73.40	96.80	720.00	400.00	500.00	500.00
8.	COD	440.00	630.00	430.00	540.00	10.00	10.00

Source: Laboratory Analysis, 2020.

Table 4: Physico-chemical Properties of Well Water in Samaru New Extension during Rainy Season (August)

S/N	Parameter Mg/l	Borehole Close to	Borehole Far away	Hand dug well Close to	Hand dug well Far away	WHO (2011) Standard	NSDWQ (2007) Standard
1.	pH (Unit)	5.97	5.88	6.72	7.22	6.5-8.5	6.5-8.0
2.	Colour(Unit)	5.00	5.00	5.00	5.00	5.00	5.00
3.	DO	1.32	1.35	1.32	1.41	3.00	3.00
4.	BOD	0.30	1.10	0.40	0.50	0.8-5.0	0.8-5.0
5.	Chloride	51.20	14.31	74.48	15.21	200.00	200.00
6.	TH	253.40	303.90	655.00	520.00	400.00	400.00
7.	TDS	107.40	86.60	710.00	375.00	500.00	500.00
8.	COD	461.00	640.00	450.00	555.00	10.00	10.00

Source: Laboratory Analysis, 2020.

Table 5: Physico-chemical Properties of Well Water in Hayin Dogo during Dry Season (April)

S/N	Parameter Mg/l	Borehole Close to	Borehole Further away	Hand dug well Close to	Hand dug well Further away	WHO (2011) Standard	NSDWQ (2007) Standard
1.	pH (Unit)	6.91	7.54	5.61	6.72	6.5-8.5	6.5-8.0
2.	Colour (Unit)	5.00	5.00	5.00	5.00	5.00	5.00

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3.	DO	1.31	5.23	1.70	3.70	3.00	3.00
4.	BOD	1.10	0.60	1.00	0.40	0.8-5.0	0.8-5.0
5.	Chloride	14.20	11.31	12.99	13.40	200.00	200.00
6.	TH	100.00	96.20	200.00	112.00	400.00	400.00
7.	TDS	416.20	104.90	738.99	285.05	500.00	500.00
8.	COD	341.00	253.00	420.00	400.00	10.00	10.00

Source: Laboratory Analysis, 2020.

Table 6: Physico-chemical Properties of Well Water in Hayin Dogo during Rainy Season (August)

S/N	**Parameter**	**Borehole**		**Hand dug well**		**WHO (2011) Standard**	**NSDWQ (2007) Standard**
	Mg/l	**Close to**	**Further away**	**Close to**	**Further Away**		
1.	pH (Unit)	5.01	5.61	5.86	5.89	6.5-8.5	6.5-8.0
2.	Colour (Unit)	5.00	5.00	5.00	5.00	5.00	5.00
3.	DO	2.40	2.21	1.10	3.15	3.00	3.00
4.	BOD	0.90	0.20	0.80	0.40	0.8-5.0	0.8-5.0
5.	Chloride	43.49	30.49	15.21	13.11	200.00	200.00
6.	TH	224.00	116.00	326.30	115.30	400.00	400.00
7.	TDS	722.10	240.20	529.00	274.00	500.00	500.00
8.	COD	456.00	410.00	300.00	274.00	10.00	10.00

Source: Laboratory Analysis, 2020.

Table 7: Physico-chemical Properties of Well Water in Danraka during Dry Season (April)

S/N	**Parameter**	**Borehole**		**Hand dug Well**		**WHO (2011) Standard**	**NSDWQ (2007) Standard**
	Mg/l	**Close to**	**Further away**	**Close to**	**Further Away**		
1.	pH (Unit)	7.19	7.49	5.11	6.21	6.5-8.5	6.5-8.0
2.	Colour (Unit)	5.00	5.00	5.00	5.00	5.00	5.00
3.	DO	5.41	2.20	6.69	3.20	3.00	3.00
4.	BOD	0.90	1.70	1.10	1.50	0.8-5.0	0.8-5.0
5.	Chloride	11.21	9.23	14.10	12.38	200.00	200.00
6.	TH	210.10	6.21	440.00	120.00	400.00	400.00
7.	TDS	113.60	141.80	510.70	210.00	500.00	500.00
8.	COD	450.00	623.00	550.00	660.00	10.00	10.00

Source: Laboratory Analysis, 2020.

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Table 8: Physico-chemical Properties of Well Water in Danraka during the Rainy Season (August)

S/N	Parameter	Bore hole		Hand dug well		WHO (2011) Standard	NSDWQ (2007) Standard
	Mg/l	Close to	Far away	Close to	Far away		
1.	pH (Unit)	5.73	6.21	5.21	5.31	6.5-8.5	6.5-8.0
2.	Colour (Unit)	5.00	5.00	5.00	5.00	5.00	5.00
3.	DO	4.10	1.11	5.38	2.42	3.00	3.00
4.	BOD	0.70	1.40	1.01	1.30	0.8-5.0	08-5.0
5.	Chloride	17.32	18.16	18.33	19.10	200.00	200.00
6.	TH	121.40	106.80	450.0	123.00	400.00	400.00
7.	TDS	120.00	107.00	500.12	21.01	500.00	500.00
8.	COD	623.00	674.00	570.00	680.00	10.00	10.00

Source: Laboratory Analysis, 2020.

A statistical t – test was carried out to test the significant difference between the samples collected during dry and rainy season which are presented in Table 9 and Table 10. The result shows that there is no significant difference between the seasons because the calculated t value is less than the Tabulated t value. This is also an indication that the wells irrespective of the season are both contaminated by the dumpsite.

Table 9: Test for Difference in Physico-Chemical Well Water Quality for Boreholes in Samaru during the Dry (April) and Rainy (August) Season

Location	Season	Calculated t	Tabulated t	Significance
Samaru	Dry Season	0.015	2.365	Not significant
New Extension	Rainy Season	0.46	2.365	Not significant
Hayin Dogo	Dry season	0.46	2.365	Not significant
	Rainy Season	0.49	2.365	Not significant
Danraka	Dry Season	0.003	2.365	Not significant
	Rainy season	0.14	2.365	Not significant

Source: Laboratory Analysis, 2020

Table10: Test for Difference in Physico-Chemical Well Water Quality for Hand dug Wells in Samaru during Dry (April) and Rainy (August) Season

Location	Season	Calculated t	Tabulated t	Significance
Samaru	Dry Season	0.38	2.365	Not significant
New Extension	Rainy Season	0.40	2.365	Not significant
Hayin Dogo	Dry season	0.44	2.365	Not significant
	Rainy Season	0.23	2.365	Not significant
Danraka	Dry Season	0.41	2.365	Not significant
	Rainy season	0.46	2.365	Not significant

Source: Laboratory Analysis, 2020

The mean value of the parameters for both seasons for the well were determine and presented in Table 11 and Table 13 alongside the WHO standard and chi square test was carried out to check the significance difference of the results when compare to the WHO standard and the result is presented in Table 12 and Table 14. The result in Table 12 and Table 14 shows that there is significant difference between the measured parameters and the WHO standard because the

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calculated value is more than the Tabulated value. Same test was carried out for the borehole sample which shows significance difference the results are presented in Table 15 to Table 18.

Table11: Mean Physico-Chemical Concentration and the WHO Guidelines for Hand dug Wells Close to Dumpsite during Dry and Rainy Season

S/NO	Parameter	Result during dry season	Result during rainy season	WHO Guidelines
1	pH	5.88	5.90	7.5
2	Colour	5.00	5.00	5.0
3	DO	3.30	3.28	3.0
4	BOD	0.90	0.74	5.0
5	Chloride	31.16	36.00	200.0
6	TH	428.80	477.10	400.0
7	TDS	656.56	579.71	500.0
8	COD	466.67	440.00	10.0

Source: Laboratory Analysis, 2020

Table12: Relationship between observed and Expected Value of Chemical Concentration in Water Samples

Well type	Season	Calculated X^2	Tabulated X^2	Significance
Shallow	Dry Season	21,021.37	14.07	Significant
Well	Rainy Season	18,656.18	14.07	Significant

Source: Laboratory Analysis, 2020

Table 13: Mean Physico-Chemical Concentration and WHO Guidelines for Hand dug wells far from Dumpsite during the Dry and Rainy season

S/NO	Parameter	Result during dry season	Result during rainy season	WHO Guidelines
1	pH	7.44	6.13	7.5
2	Colour	5.00	5.00	5.0
3	DO	2.83	2.33	3.0
4	BOD	0.93	0.73	5.0
5	Chloride	12.76	15.81	200.0
6	TH	249.03	252.77	400.0
7	TDS	298.35	286.67	500.0
8	COD	533.33	503	10.0

Source: Laboratory Analysis, 2020

Table 14: Relationship between Observed and Expected Value of Physico- Chemical Concentration in Well Water Sample

Well type	Distance	Season	Calculated X^2	Tabulated X^2	Significance
Shallow	Far from	Dry Season	19,094.50	14.07	Significant
Well	Dumpsite	Rainy Season	24,618.79	14.07	Significant

Source: Laboratory Analysis, 2020

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Table 15: Mean Physico-Chemical Concentration and WHO Guidelines for Boreholes close to Dumpsite during the Dry and Rainy Season

S/NO	Parameter	Result during dry season	Result during rainy season	WHO Guidelines
1	pH	6.77	5.57	7.5
2	Colour	5.00	5.00	5.0
3	DO	2.81	2.60	3.0
4	BOD	0.83	0.63	5.0
5	Chloride	23.24	137.34	200.0
6	TH	187.17	199.60	400.0
7	TDS	201.07	316.6	500.0
8	COD	401.33	513.33	10.0

Source: Laboratory Analysis, 2020

Table 16: Relationship between Observed and Expected value of Phyisco-Chemical Concentration in Well Water Samples

Well type	Distance	Season	Calculated X^2	Tabulated X^2	Significance
Deep Well	Close - to <10m Dumpsite	Dry Season	16,478.15	14.07	Significant
		Rainy Season	25,638.51	14.07	Significant

Source: Laboratory Analysis, 2020

Table 17: Mean Physico-Chemical Concentration and WHO Guidelines for Boreholes far from Dumpsite during the Dry and Rainy Season

S/NO	Parameter	Result during dry season	Result during rainy season	WHO Guidelines
1	pH	7.23	6.90	7.5
2	Colour	5.00	5.00	5.0
3	DO	2.94	1.55	3.0
4	BOD	1.20	0.90	5.0
5	Chloride	10.27	20.99	200.0
6	TH	134.54	175.57	400.0
7	TDS	144.50	1144.60	500.0
8	COD	502.00	574.67	10.0

Source: Laboratory Analysis, 2020

Table 18: Relationship between observed and Expected Value of Physico-chemical Concentration in Well Water Samples

Well type	Distance	Season	Calculated²	Tabulated²	Significance
Deep Well	Far from Dumpsite >150m	Dry Season	32,428.38	14.07	Significant
		Rainy Season	24,818.32	14.07	Significant

Source: Laboratory Analysis, 2020

CONCLUSION

The result obtained from this study shows that the groundwater of Samaru is not totally pure. A high level of contamination was recorded for some of the parameters that were analyzed. It can therefore be concluded that the groundwater of the study area especially wells close to dumpsites is not good enough for direct consumption following evidence of high, COD in most of the wells. From the result obtained in the analysis, it can also be said that dumpsites alone

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are not responsible for groundwater contamination of the study area, but geology of the study area, and some previous land use practices such as mechanic shop, abattoir soil type and geologic factors can also be responsible for groundwater contamination.

From the test and results obtained from the research it was discovered that the physico-chemical properties of well water for both shallow and deep wells in the study area fall within the acceptable limits of the WHO standards except for COD which has a very high value ranging between 400-600 mg/l while the WHO standard is 10mg/l.

RECOMMENDATIONS

Based on the results obtained from this study, the following recommendations become necessary:

i. The use of water from shallow wells that are near to waste dumpsites should be restricted to other domestic usage other than consumption.
ii. The authority in charge of water supply in the area should further evaluate the water, then make provision for purification before the end users take the water for domestic usage. This is to reduce the concentration of the pollutants.
iii. There is an urgent need for legislation that will stop the dumping of waste within the residential area. This will help in improving the sanitary condition of the wells.
iv. Residents using shallow wells are advised to construct the wells in such a way that they can close them tightly to avoid contamination from waste moved by wind and surface run-off during the raining season.
v. Dumpsites should be fumigated to reduce the menace of breeding of vectors such as mosquitoes (malaria), houseflies (cholera), worms and others. Such water should be treated by employing some measures such as the use of disinfectants or boiling before use which will help reduce the pollutants, but majorly an improved water supply to the study area will go a long way to correct the unhealthy conditions.

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