BEST: International Journal of Humanities, Arts,
Medicine and Sciences (BEST: IJHAMS)
ISSN 2348-0521
Vol. 2, Issue 5, May 2014, 1-10
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EFFECT OF DUMPSITES ON GROUND WATER QUALITY IN ZARIA METROPOLIS, KADUNA STATE, NIGERIA

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ABSTRACT

This study was aimed at determining water quality parameters in deep and shallow wells water from Zaria, Nigeria. In order to assess the quality of the water from the wells, water samples were collected from forty shallow and twenty deep wells close to waste dumpsites. Parameters for quality check include; pH, biological oxygen demand, dissolved oxygen, colour, turbidity, dissolved sediments, suspended sediment, and chemical oxygen demand. The physicochemical characteristics were determined using their respective standard methods of analysis. The overall results from this study showed that both deep and shallow wells water sampled have colour, TSS and TDS that fall within the WHO acceptable standard. Only 32.5% of the shallow wells have turbidity values within the WHO standard, 20% of the deep wells have the turbidity values that fall above the WHO standard. All the deep and shallow wells have pH and BOD values that meet the WHO standard. 37.5% of the sampled shallow wells have COD that fall within the WHO standard, while 75% of the deep wells meet the WHO standard. 10% of the shallow wells and 20% of the deep wells have CO values that meet the WHO standard. The correlation values show a negative relationship between the parameter assessed and the distance of the wells from the dumpsites. The concentration reduce with increase in distance away from the dumpsites. The twenty deep wells sampled appear to be safer in quality than the shallow wells. It is recommended that other parameters such as heavy metals cation and anion should be measured.

KEYWORDS: Shallow Wells, Water Bodies, Humans and Livestock

INTRODUCTION

Water is a colorless, odorless and tasteless substance. Chemically, it is a product of chemical reaction between hydrogen and oxygen. It exist in both liquid, solid and gaseous forms. Water is an essential resource with an unparalleled value after air. There is virtually no area of life that water is not important, be it flora, or fauna (biosphere), in the air (atmosphere) and in the rock system (lithosphere). Every day, new use of water are coming up due to increase in technologies that require water (Smith, 1972)

Water quality is a term used to describe the chemical, physical, and biological characteristics of water, generally in terms of suitsability for a particular or designated use. Contamination of water bodies has increasingly become an issue of serious environmental concern. Clean water is a priceless and limited resource that man has began to treasure only recently after decades of pollution and waste (Okoye and Nwagbogwu, 2012). Potable water is an essential ingredient for good health and the socio-economic development of man (Zakrzewski, 2002), but it is lacking in many societies. All natural waters contain many dissolved substances. Contaminants such as bacteria, viruses, heavy metals, nitrates and salt have polluted water supplies as a result of inadequate treatment and disposal of waste from humans and livestock, industrial discharges, and over-use of limited water resources.

The major sources of pollution in streams, rivers and underground water arises from anthropogenic activities largely caused by the poor and uncultured living habit of people as well as the unhealthy practices of factories, industries and corporate bodies; resulting in the discharge of effluents and untreated wastes. Pollution in water affects not only water quality but could also be dangerous to aquatic life (Jayalakshmi, Lakshmi, and Singara, 2011). Ground water pollution could be avoided when borehole wells are located far from any source of potential pollution. Good well design is also important in the prevention of underground water pollution. During the construction process of a borehole, drilling fluids, chemical casings and other materials may find their way into the well thereby polluting the water. An open hole during the construction stage can also be a direct route for contaminants from the surface to the aquifer thereby providing an ideal opportunity for chemical and bacteriological pollution to occur. Deep and shallow wells water serves as the major source of drinking water in the local population of the developing countries, since only very few can afford and rely on purified and treated bottled water for consumption. Owners of boreholes capitalize on this opportunity to commercialize their boreholes which many resort to buying the bore hole water for drinking, since it is cheaper for them to afford. Because of these constraints, the poorest fraction of the population are often left with no option, but to rely on the shallow well for supply of their domestic water (Zakrzewski, 2002).

The threats ground water quality come from a range of sources and the type and extent of water pollution varies by location, ecosystem characteristics, land-use and the degree and type of development. Pathogenic bacteria and viruses are found in areas where untreated sewage and effluents from intensive animal husbandry operations drain into waterways. They also enter water supplies from storm water run-off, or as a result of leaching from open solid waste dumpsites or agricultural areas where untreated wastewater is used on crops (Wheather, Marx, Jawal, and Oragin, 1980).

The level of pathogens is usually in direct proportion to the density of population and level of socio-economic development in proximity to the water. The sewerage systems in many of the developing countries of the world are poorly developed and only 10 per cent of wastewater undergoes any form of treatment (WHO, 1993). Many of the region’s rivers contain up to three times as much bacteria from human waste (faecal coliform) as the world average and more than ten times the standards set out in the OECD guidelines.

The reported median fecal coliform count in the rivers of the Asian landmass, for instance, is 50 times higher than the WHO guidelines and is even more serious in the Southeast Asian sub-region (Prickering, 1994). Drinking or bathing in water contaminated by animal or human excreta facilitates transmission and proliferation of disease vectors. The most common water-borne infectious and parasitic diseases include hepatitis a, diarrhoea diseases, typhoid, roundworm, guinea worm, leptospirosis, and schistomiasis . Organic matter also constitutes a significant pollutant in the water bodies o, with industries such as pulp and paper, textile, tanneries and food processing contributing substantially. The geographic distribution of organic matter pollution largely coincides with that of pathogenic contamination (Tebbutt, 1998).

Because of the essential role played by water in supporting human life, it also has if contaminated, great potentials for transmitting a wide variety of diseases and illnesses. In developed worlds, water related diseases are rare, due to the presence of an efficient water supply and wastewater disposal system.

However, in developing worlds, perhaps as many as 1.3 thousand million people are without portable water supply and almost 2 thousand million do not have adequate sanitation. As a result, the toll of water related diseases in these areas is frightening in its extent. Millions of people die each year as the consequence of unsafe water or inadequate sanitation. As a result, the toll of water related diseases in these areas is frightening in its extent. Millions of people die each year as the consequences of unsafe water of inadequate sanitation, and although exact information is difficult to obtain, the World Health Organization (WHO) data gives an indication of the magnitude of the problem (WHO, 2004).

The scourge of water borne diseases still reigns supreme in most developing countries, compared to the developed world, where water borne disease outbreaks are very rare . In Nigeria today, the story is not any different as it was made known that current medical reports claim that water borne diseases are second commonest diseases after malaria in the country. Improved access to quality water can bring about a dramatic reduction of these diseases (Adejoke, 1990).

In order to be able to make sensible connections between water and disease, it is not only necessary to have some knowledge of the organisms which cause disease, but also to be aware of the mechanism by which water relate disease transmission can occur. In addition, it is necessary to appreciate the strengths and weaknesses of the bacteria indicator system that is widely employed to assess the potential dangers associated with polluted water (Pimental, 2007).

The classical water borne diseases are due to highly infective organisms, where only rather few are needed to infect somehow relative to the level of pollution that readily occurs. The two chief ones, which have a high mortality if untreated and are diseases which community is very anxious to escape, are typhoid and cholera. Both are caused by relatively fragile organisms whose sole reservoir is man. Others are bacillary dysentery, shigellosis etc. typhoid and cholera occur most dramatically as a common source outbreak where community’s water gets contaminated by faeces from a person suffering from one of the infections. Many people drink the water and a number of these falls ill from the infection at about the same time. It is this sudden appearance of a cluster of cases combined with their severity that makes the illnesses so feared (Pimental, 2007).

Like any other major city in Nigeria, Zaria is faced with the problem of waste management. Shallow and deep wells are often found near major dumpsites. Therefore, this brings the imperativeness of examining the water quality parameters of deep and shallow wells water in the study area.

The Study Area

Zaria is one of the ancient cities in Nigeria. The town is located at about 83km to the north of Kaduna Metropolis, with latitudinal location of between 11°03’-11°13’North, and Longitudinal location of between 7°36’-7°45’ East . It is a trade centre and a major transportation hub for the surrounding agricultural areas with its rail and road junction. Zaria has a tropical continental climate type characterized by wet and dry season. The natural vegetation of the study area is that of the Northern Guinea Savannah. The soils in the study area has been classified as tropical ferruginous soil. They are zonal soils developed under climatic regimes with appreciable but seasonal rainfall of 500-1200mm and cover nearly half of Northern Nigeria (Oguntoyinbo, 1983).

The soil material consists of several feet of deposited silt sand overlaying sedimentary decomposed rock. The soil is poorly drained because of the high percentage of fine textured materials in the upper layers, which results to water logging especially during the rainy season and tends to dry out and cracks during season. The geology of the area is part of the basement complex geology of central Nigeria.

The drainage system consists of Kubanni River, a tributary of Galma River which runs into river Kaduna and characterized by high stream frequencies and drainage density. Other rivers are; Saye, Shika and Yashi Rivers. These rivers form the major drainage channels of the study area (Thorp, 1970)

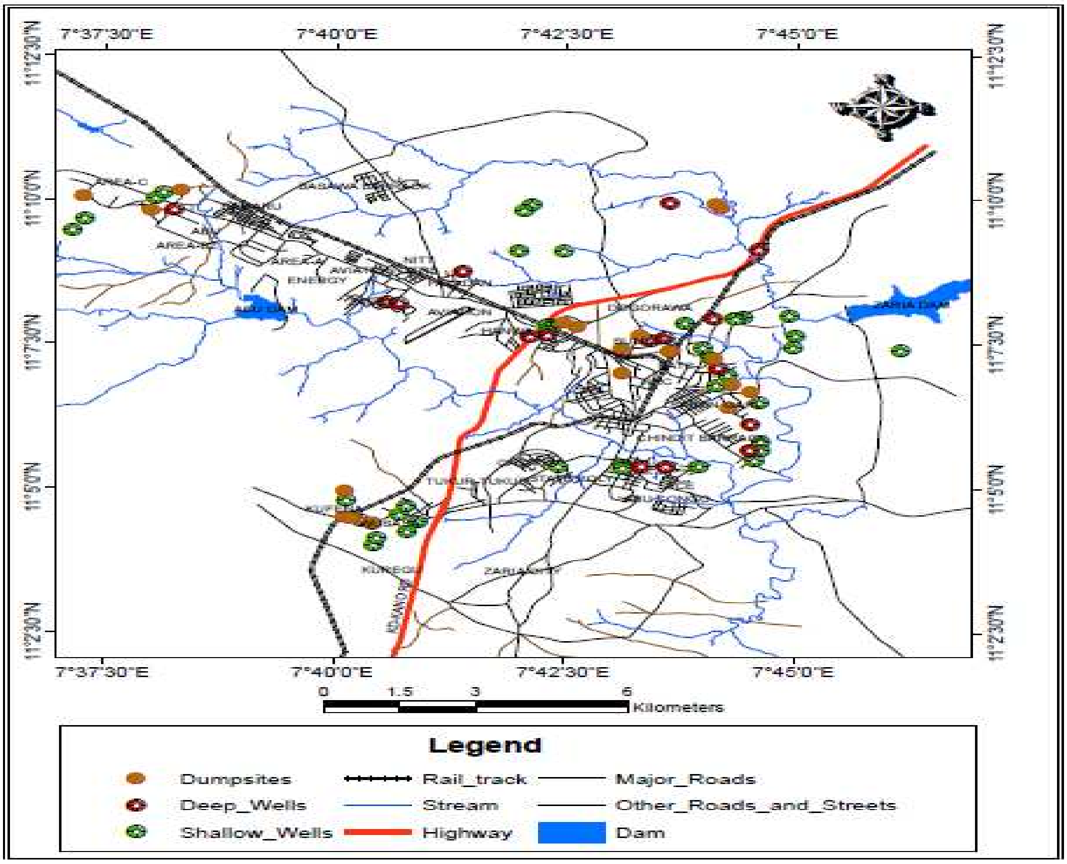

Figure 1: Zaria Metropolis

METHODOLOGY

Sample Collection, Treatment and Preservation

Major dumpsites from ten areas (Dogarawa, Gaskiya, Jushi, Kwangila, Muchia, Sabon-Gari, Samaru, Tudun-Wada, Wusasa, and Zaria city) were located. Forty shallow and twenty deep wells (closest wells to each major dumpsite). Water samples were collected directly from the wells into clean polyethylene stopper bottles which have been washed with soap solution, rinsed three times with pure water and then rinsed again three times with 1% HNO_3 after which they were rinsed with the well water to be collected. The water samples were collected and labeled.

Sample Analysis

PH and turbidity were determined using digital pH and turbidity meters. The colour of the water samples was determined with the aid of lovibond disc comparator. Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) were determined using standard methods (Bertram and Balance, 1996; National Water Supply Training Network, 1997).

Data Analyses

The data obtained from laboratory analyses were analyzed using Pearson bivariate correlation to examine the relationship between the distance of well from dump site and physicochemical characteristics of the water. WHO standards were also used to compare the quality of deep and shallow wells.

RESULTS AND DISCUSSIONS

Table 1 compared the concentration of the parameters with the WHO acceptable standard to examine the quality of the wells. The result shows that; the pH of the forty shallow and twenty deep wells fall within the WHO acceptable standard. The minimum pH value is 6.12, while the maximum value is 9.26. Compared with the WHO standard of 6.5-8.5, all the wells meet the standards for pH except a deep well with pH value of 9.26 tending towards alkalinity. Similarly, the colour of the water from both the shallow and deep wells fall within the WHO standard of 15 units. The turbidity values of the shallow wells is greater than the WHO acceptable level. This indicates that the quality of the well water in the study area with respect to turbidity level, is below the WHO standard.

Table 1: Parameters Concentration and WHO Standard

	DISTANCE (M)	pH	COLOUR (Unit)	TURBIDITY (Unit)	BOD (mg/l)	COD (mg/l)	DO (m/l)	TSS (m/l)	TDS (m/l)
WHO STANDARD		6.5-8.5	15.00	5.00	5.00	40.00	<4	500	1000
SHALLOW WELL 1	10.00	6.26	5.00	15.00	0.92	330	3.30	73	80.0
SHALLOW WELL 2	11.00	6.29	5.00	11.00	0.86	150	3.00	50	160
SHALLOW WELL 3	12.00	6.30	5.00	8.00	0.80	140	2.10	45	70
SHALLOW WELL 4	12.50	6.34	5.00	5.80	0.77	138	2.00	20	210
SHALLOW WELL 5	18.00	6.85	5.00	2.80	0.60	130	2.20	3	69
SHALLOW WELL 6	21.50	6.8	5.00	2.40	0.50	190	1.90	2	62
SHALLOW WELL 7	23.00	7.0	5.00	1.80	0.80	100	1.80	2	70
SHALLOW WELL 8	14.00	7.5	5.00	1.70	0.40	60	1.20	2	23
SHALLOW WELL 9	24.00	6.44	8.00	7.00	0.30	150	2.70	1.3	49
SHALLOW WELL 10	24.00	6.7	5.00	7.50	0.30	101	2.00	1.00	46
SHALLOW WELL 11	46.00	6.9	5.00	4.70	0.10	98	1.60	1.00	38
SHALLOW WELL 12	48.00	7.2	5.00	4.20	0.10	100	1.50	2.2	44
SHALLOW WELL 13	3.00	7.39	10.00	5.28	2.20	7.50	2.40	50	150
SHALLOW WELL 14	20.00	7.34	5.00	2.32	1.60	6.40	3.20	20	70
SHALLOW WELL 15	3.00	7.41	10.00	7.57	2.30	8.50	2.80	40	700
SHALLOW WELL 16	4.00	7.39	8.00	7.55	2.22	8.60	2.20	40	580
SHALLOW WELL 17	2.00	6.68	4.50	2.90	2.70	4.1	1.50	3.0	170
SHALLOW WELL 18	9.00	6.70	5.00	2.70	1.90	3.5	1.50	2.8	168
SHALLOW WELL 19	20.00	6.71	5.00	2.50	0.70	2.9	1.80	2.2	140
SHALLOW WELL 20	28.00	6.94	3.50	1.60	0.60	2.2	1.80	2.0	138
SHALLOW WELL 21	3.40	7.80	5.00	25.00	1.80	132	3.00	0.13	0.01
SHALLOW WELL 22	6.80	7.51	4.90	25.00	1.30	105	2.80	0.28	0.23
SHALLOW WELL 23	8.40	7.23	5.00	18.00	0.80	100	1.50	0.18	0.48
SHALLOW WELL 24	17.00	7.18	4.00	14.00	0.65	150	0.90	0.13	0.21
SHALLOW WELL 25	8.60	6.57	5.00	10.00	0.40	4.0	1.40	10	200
SHALLOW WELL 26	13.0	5.84	5.00	13.00	0.50	2.4	1.20	4.00	100
SHALLOW WELL 27	18.4	6.32	5.00	9.00	0.30	2.0	1.70	2.00	10
SHALLOW WELL 28	12.00	8.10	5.00	2.00	6.50	13.00	9.90	3.00	76
SHALLOW WELL 29	18.00	8.20	5.00	4.00	4.90	9.80	12.1	3.00	42
SHALLOW WELL 30	9.50	7.50	5.00	8.00	3.30	10.20	13.6	6.00	160
SHALLOW WELL 31	15.60	7.80	5.00	6.00	5.10	13.00	7.00	4.00	120
SHALLOW WELL 32	92.36	6.69	5.00	5.50	1.10	250	1.90	3.90	1.40
SHALLOW WELL 33	316	6.58	5.00	6.00	1.00	240	1.80	3.80	1.20
SHALLOW WELL 34	568	6.92	5.00	5.30	1.30	270	1.60	3.00	1.45
SHALLOW WELL 35	425	6.71	5.00	5.90	1.10	210	1.90	3.95	1.42
SHALLOW WELL 36	5.70	7.72	5.00	8.62	2.50	425	2.90	4.00	12.2
SHALLOW WELL 37	4.60	7.50	5.00	2.80	2.20	320	2.40	2.12	1.32
SHALLOW WELL 38	6.10	7.89	5.00	4.28	2.00	575	3.50	4.20	3.82
SHALLOW WELL 39	12.10	7.41	5.00	7.20	2.50	400	2.85	5.00	1.50
SHALLOW WELL 40	13.70	7.35	5.00	3.14	0.65	205	2.95	3.12	2.81
DEEP WELL 1	8.00	6.08	5.00	4.10	1.57	125	3.10	80.0	310
DEEP WELL 2	10.00	6.12	5.00	3.20	0.09	70.0	3.00	63.0	185
DEEP WELL 3	28.00	9.26	3.50	17.00	1.40	180	2.40	2	20
DEEP WELL 4	49.00	6.6	5.00	1.60	0.90	100	2.40	2.2	49
DEEP WELL 5	24.00	6.90	5.00	1.50	0.80	100	2.00	2.0	44.0
DEEP WELL 6	20.00	7.60	5.00	0.39	0.20	7.50	2.80	10	310
DEEP WELL 7	10.00	6.94	2.00	1.80	0.90	2.20	1.80	2.0	140
DEEP WELL 8	6.00	6.97	3.00	2.50	0.70	3.00	1.80	2.2	138
DEEP WELL 9	18.00	7.50	4.00	8.00	0.40	0.90	18.0	0.05	0.02
DEEP WELL 10	10.00	7.50	4.00	8.00	0.80	0.98	11.0	0.02	0.08
DEEP WELL 11	25.00	7.61	4.00	8.20	0.20	0.84	11.0	0.04	0.06
DEEP WELL 12	12.50	7.50	5.00	2.00	0.60	4.00	1.80	21	50.0

Table 1: Contd.,

DEEP WELL 13	55.50	6.30	5.00	4.00	0.30	2.40	1.90	5.00	25.0
DEEP WELL 14	3.20	6.70	5.00	2.00	0.70	2.90	1.60	2.00	18.0
DEEP WELL 15	28.40	7.60	3.50	0.90	0.83	4.52	0.80	3.70	2.40
DEEP WELL 16	13.60	7.20	4.00	0.30	0.47	3.10	0.79	2.56	3.10
DEEP WELL 17	9.30	6.90	5.00	0.72	0.20	2.80	6.20	3.00	4.20
DEEP WELL 18	120	6.55	5.00	2.10	0.90	3.00	1.40	2.00	1.10
DEEPWELL 19	45.00	6.60	5.00	2.00	0.80	2.00	1.50	19.0	1.00
DEEP WELL 20	16.80	7.20	4.50	0.90	0.40	1.80	0.54	8.00	0.56

Source: Field Survey, 2013

However, the biological oxygen demand of the sampled wells shows that there are organism in the water sampled, all the shallow wells fall above WHO acceptable standard, this is not far from the result of Omofonmwa and Eseigbe (2009) research in Benin, Nigeria. The BOD of most of the sampled wells fall within the WHO acceptable limit for BOD is 6-7. The chemical oxygen demand of 90% of the well is far greater than WHO acceptable limit of 10-20. Only 10% 0f the wells sampled have BOD that is within the WHO acceptable standard. Both the total dissolved and total suspended solids are within the WHO acceptable limits.

The correlation results for both deep and shallow wells are presented in tables 2 and 3 bellow. From the tables 2and 3, it can be deduced that there is a strong negative relationship between all the physiochemical parameters analyzed. In other words, the result shows that increase in distance of a well away from the dumpsite leads to reduction in the concentration of the whole parameters analyzed. However, the relationship is not statistically significant at both 0.05 and 0.01significant levels.

One can then make a generalization that, though distance of a well from the dump site affect the quality of the wells, its is not the only factor. Other factors such as geology of the underline rocks may also be some major factors. This result is almost similar with what Nioufer, Syamala, and Swamy (2013), discovered in their analysis of the impact of Municcipal Waste on ground water quality in Vijayawada city, Andhar Pradesh.

Table 2: Correlation Table of Distance from the Dupsite and the Biophysicochemical Parameters of the Deep Wells

Correlations										
		Distance	**PH**	**Colour**	**Turbidity**	**BOD**	**COD**	**DO**	**TSS**	**TDS**
Distance	Pearson Correlation	1	-.165	.274	-.026	.128	-.024	-.174	-.205	-.281
	Sig. (2-tailed)		.486	.242	.914	.592	.919	.464	.386	.229
	N	20	20	20	20	20	20	20	20	20
PH	Pearson Correlation	-.165	1	-.426	.641**	.133	.189	.220	-.469*	-.264
	Sig. (2-tailed)	.486		.061	.002	.577	.425	.352	.037	.260
	N	20	20	20	20	20	20	20	20	20
Colour	Pearson Correlation	.274	-.426	1	-.271	-.203	.103	-.103	.337	.050
	Sig. (2-tailed)	.242	.061		.249	.391	.665	.667	.146	.836
	N	20	20	20	20	20	20	20	20	20
Turbidity	Pearson Correlation	-.026	.641**	-.271	1	.324	.488*	.460*	-.069	-.174
	Sig. (2-tailed)	.914	.002	.249		.163	.029	.041	.774	.464
	N	20	20	20	20	20	20	20	20	20
BOD	Pearson Correlation	.128	.133	-.203	.324	1	.609**	-.249	.203	.129
	Sig. (2-tailed)	.592	.577	.391	.163		.004	.290	.391	.588
	N	20	20	20	20	20	20	20	20	20
COD	Pearson Correlation	-.024	.189	.103	.488*	.609**	1	-.166	.385	.276
	Sig. (2-tailed)	.919	.425	.665	.029	.004		.483	.094	.239
	N	20	20	20	20	20	20	20	20	20
DO	Pearson Correlation	-.174	.220	-.103	.460*	-.249	-.166	1	-.150	-.188
	Sig. (2-tailed)	.464	.352	.667	.041	.290	.483		.529	.427
	N	20	20	20	20	20	20	20	20	20
TSS	Pearson Correlation	-.205	-.469*	.337	-.069	.203	.385	-.150	1	.656**
	Sig. (2-tailed)	.386	.037	.146	.774	.391	.094	.529		.002
	N	20	20	20	20	20	20	20	20	20
TDS	Pearson Correlation	-.281	-.264	.050	-.174	.129	.276	-.188	.656**	1

Table 2: Contd.,

	Sig. (2-tailed)	.229	.260	.836	.464	.588	.239	.427	.002	
	N	20	20	20	20	20	20	20	20	20

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The result shows that, most parameters have strong and significant relationship among themselves. There is a significant relationship between colour and biological oxygen demand at both 0.01 and 0.05 significant level. Similarly, colour and Dissolved oxygen demand show a significant relationship. Other parameters that show significant relationship include; colour and turbidity.

Table 3: Correlation Table of Distance from the Dupsite and the Biophysicochemical Parameters of the Shallow Wells

Correlations										
		Distance	**pH**	**Colour**	**Turbidity**	**BOD**	**COD**	**DO**	**TSS**	**TDS**
Distance	Pearson Correlation	1	-.164	-.095	-.107	-.105	.235	-.140	-.146	-.216
	Sig. (2-tailed)		.311	.559	.512	.518	.145	.388	.368	.181
	N	40	40	40	40	40	40	40	40	40
pH	Pearson Correlation	-.164	1	.100	-.025	.675**	.094	.539**	-.234	-.012
	Sig. (2-tailed)	.311		.539	.878	.000	.565	.000	.146	.943
	N	40	40	40	40	40	40	40	40	40
sColour	Pearson Correlation	-.095	.100	1	-.017	.103	-.181	-.017	.477**	.633**
	Sig. (2-tailed)	.559	.539		.916	.527	.263	.917	.002	.000
	N	40	40	40	40	40	40	40	40	40
Turbidity	Pearson Correlation	-.107	-.025	-.017	1	-.126	.053	-.069	.129	-.086
	Sig. (2-tailed)	.512	.878	.916		.438	.745	.670	.429	.596
	N	40	40	40	40	40	40	40	40	40
BOD	Pearson Correlation	-.105	.675**	.103	-.126	1	-.103	.768**	-.006	.154
	Sig. (2-tailed)	.518	.000	.527	.438		.529	.000	.970	.344
	N	40	40	40	40	40	40	40	40	40
COD	Pearson Correlation	.235	.094	-.181	.053	-.103	1	-.164	-.005	-.416**
	Sig. (2-tailed)	.145	.565	.263	.745	.529		.313	.975	.008
	N	40	40	40	40	40	40	40	40	40
DO	Pearson Correlation	-.140	.539**	-.017	-.069	.768**	-.164	1	-.024	.027
	Sig. (2-tailed)	.388	.000	.917	.670	.000	.313		.885	.868
	N	40	40	40	40	40	40	40	40	40
TSS	Pearson Correlation	-.146	-.234	.477**	.129	-.006	-.005	-.024	1	.484**
	Sig. (2-tailed)	.368	.146	.002	.429	.970	.975	.885		.002
	N	40	40	40	40	40	40	40	40	40
TDS	Pearson Correlation	-.216	-.012	.633**	-.086	.154	-.416**	.027	.484**	1
	Sig. (2-tailed)	.181	.943	.000	.596	.344	.008	.868	.002	
	N	40	40	40	40	40	40	40	40	40

**.Correlation is significant at the 0.01 level (2-tailed).
*.Correlation is significant at the 0.05 level (2-tailed).

CONCLUSIONS AND RECOMMENDATIONS

The primary aim of this study was to assess the quality of shallow and deep wells in Zaria. Forty shallow wells and twenty deep wells were sampled and analyzed in the laboratory. The result from the laboratory were then correlated with distance of the wells from the dumpsites. The research finding from the sampled wells shows that the wells thousands of people consume in this area are far from WHO acceptable standard. The wells due to their location near to the dumpsites have increased levels of concentration of pH, BOD, COD,DO, Turbidity, TSS, TDS, and Colour. The result also suggest that other factors such as the geologic materials, construction design of the wells, drainage and sewage systems could be other determinants of the water quality in the study area.

Therefore, it is advice that proper sanitary condition, and distance from dumpsites should be consider as the requirement for construction of wells. The depth of the well should also be considered in well construction. This is to reduce the rate of leached material down to the wells. In addition, the residents need proper education on proper waste management.

Also, since the study indicates that most of the wells in Zaria fall below the WHO standard, the following recommendations become imperative.

- The use of water from shallow wells that are near to waste dumpsites should be restricted to other domestic usage other than consumption.
- 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.
- 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.
- 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.

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