Chemical Quality of Groundwater from Hand-Dug Wells in Jos Metropolis and Environs, North-Central Nigeria.

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ABSTRACT

Water samples were obtained from 30 hand-dug wells, distributed in the different rock types within Jos, Nigeria and its environs. These samples were analyzed for chemical parameters. The nitrate elevated values where noticed to be predominant within the most developed areas resulting from sewage, pit latrines, and refuse dumps. The results in this study could be used to structure a public health program that would take into cognizance this threat to human health in health care program planning. Additionally, this study may be of benefit in selection and siting of wells for the purposes of monitoring groundwater quality based on the places where some of these parameters measured above the WHO standard. In light of the data presented in this study, adequate siting and planning of well locations is strongly suggested.

(Keywords: chemical, groundwater wells, nitrate, Jos)

INTRODUCTION

In Nigeria groundwater occurs practically every where in the country. It supplies potable water to a very large percent of the population, *in situ*, through boreholes, hand dug-wells, and springs. Groundwater provides the immediate panacea for the provision of potable water to the majority of Nigerians despite the varied climatic environments (Offodile 2000).

The study area is located within the Jos metropolis and is bounded by latitudes 10° 00′ and 9° 50′ and longitudes 9° 00′ and 8° 55′ (Figure 1). This study area covers parts of four local government areas namely Jos north, Jos south and Jos east, and Bassa local government areas of Plateau State, Nigeria. The study area covers an area of about 340 km^2, extending for about 18 km from north to south, and 18.5 km from east to west. The area is accessible through a major road passing from Toro and Zaria road in the north; it passes through Jos metropolis and heads towards Buruku at the southern end.

As Jos continues to grow in population and size, development activities would also increase. This is certainly bound to impact on the quality of the area's groundwater. This engenders issues like groundwater protection and groundwater quality monitoring and also emphasizes the need for planning development along with groundwater resources. Unfortunately, there presently is no planning of this kind in our developmental efforts in the Jos metropolis. It is hoped that the results presented in this work may improve on our present and potential uses of our groundwater. Specifically, it is hoped that the results and findings would have practical implications in the arena of groundwater resources planning.

METHODOLOGY

Water samples were obtained from 30 hand-dug wells, distributed within the different rock types within the study area and analyzed for chemical parameters. GPS positions were taken for each well point using a Garmin model 72 GPS. At each well, water samples were collected using a 75cl plastic bottle. The bottles were rinsed with ionized water before samples were collected; a cooler with ice packs was used to store the samples in the field before taken to the laboratory.

Analytical procedures for chemical parameters are generally in accordance with the specifications and standard methods of US EPA (United States Environmental Protection Agency) standard.

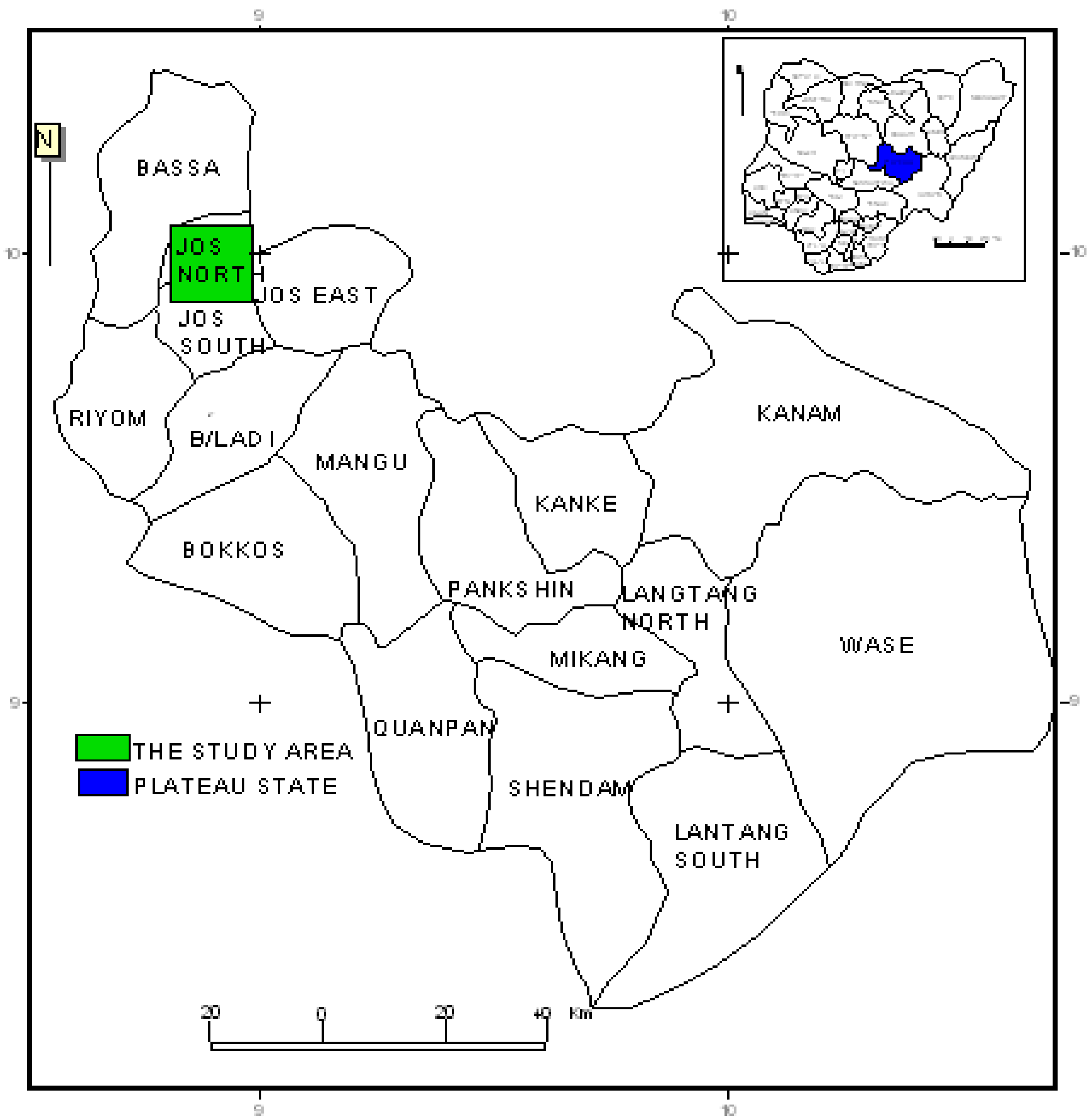


Figure 1: Plateau State Showing the Study Area.

pH was estimated using the HANNA pH meter, model HI 98129, TDS was measured using the TDS/conductivity meter (HACH) model 44600.00. Total hardness Ca^{2+}, Mg^{2+}, Cl^{-}, using the digital titrator (HACH) model 16-99-01, NO_3^{-}, Fe, Cu, SO_4^{2-}, and Mn were measured using a spectrophotometer.

RESULT AND DISCUSSION

The values of the chemical parameters in samples collected from the study area are presented below in Table 1.

<u>Anomalous Concentrations</u>: The constituents of greatest interest in this study are the nitrates and pH. These constituents registered values well beyond the acceptable WHO guideline levels.

<u>Nitrate Levels</u>: Nitrates leaches into the water-table throughout the year, although the rate of leaching depends on factors such as geology, soil type, rainfall pattern, and crop utilization rate of nitrogen, the microbial conversion rate of nitrate and fertilizer application pattern.

Table 1: Values of Chemical Parameters in the Study Area.

Samples	pH mg/l	T.D.S mg/l	Total Hardness mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	Cu^{2+} mg/l	Fe (T) mg/l	Mn^{2+} mg/l	NO_{-3} mg/l	SO_4^{2-} mg/l	Cl^- mg/l
S1	7.15	105.50	97.90	36.16	14.34	0.09	0.09	0.00	7.92	0.00	4.00
S2	7.30	95.00	70.40	28.16	10.31	0.17	0.10	0.10	17.60	4.00	7.00
S3	7.60	64.50	62.20	24.88	9.113	0.13	0.01	0.40	0.44	7.00	6.50
S4	7.25	105.00	74.70	29.88	10.94	0.01	0.01	0.00	0.44	1.00	7.00
S5	5.84	2.50	3.90	1.56	0.571	0.17	0.05	0.01	1.32	3.00	1.50
S6	7.16	61.50	34.60	13.84	5.069	0.21	0.08	0.30	11.88	5.00	6.00
S7	7.48	29.50	6.45	2.58	0.945	0.26	0.27	0.05	11.00	8.00	16.00
S8	5.33	111.00	32.20	12.88	4.717	0.15	0.05	0.02	68.20	8.00	16.00
S9	6.39	364.5	198.70	79.48	29.11	0.23	0.01	0.30	181.30	0.00	103.2
S10	6.77	61.00	22.60	9.04	3.311	0.19	0.02	0.10	7.92	0.00	12.20
S11	6.77	61.00	22.60	9.04	3.311	0.19	0.02	0.01	7.92	0.00	12.20
S12	6.08	390.00	96.50	38.60	14.14	0.25	0.00	0.30	97.24	9.00	112.60
S13	6.17	5.00	7.15	2.86	1.047	0.16	0.01	0.00	8.80	0.00	1.60
S14	5.91	19.00	6.80	2.72	0.996	0.16	0.04	0.01	19.36	0.00	3.03
S15	5.92	50.50	22.00	8.80	3.223	0.17	0.06	0.00	37.84	1.00	19.20
S16	6.01	11.50	9.60	3.84	1.406	0.15	1.17	0.30	19.36	2.00	1.70
S17	5.73	6.00	7.83	3.14	1.15	0.14	0.01	0.00	3.96	0.00	0.80
S18	6.26	2.50	6.00	2.40	0.879	0.17	0.02	0.01	2.20	1.00	0.75
S19	6.39	13.60	11.80	4.72	1.729	0.24	0.04	0.00	14.52	0.00	2.55
S20	6.65	14.00	14.60	5.84	2.139	0.35	0.16	0.60	9.68	8.00	0.90
S21	6.55	16.00	10.30	4.12	1.509	0.23	0.10	0.30	6.16	4.00	0.90
S22	6.20	62.00	37.10	14.84	5.435	0.17	0.00	0.20	21.56	17.00	6.70
S23	5.33	274.5	81.30	32.52	11.91	0.25	0.00	0.20	109.6	11.00	7.99
S24	6.60	168.5	95.20	38.08	13.94	0.17	0.01	0.20	32.12	25.00	23.30
S25	6.98	73.50	56.50	22.60	8.277	0.01	0.01	0.20	6.60	2.00	1.45
S26	7.19	88.50	64.00	25.60	9.37	0.00	0.02	0.00	21.12	1.00	8.40
S27	6.96	73.50	67.20	26.88	9.85	0.00	0.04	0.00	6.60	0.00	1.20
S28	7.14	74.00	54.10	21.64	7.93	0.20	0.03	0.10	91.96	0.00	4.45
S29	7.05	73.00	77.80	31.12	11.39	0.50	0.25	0.60	24.64	17.00	1.30
S30	5.87	179.50	74.20	29.68	10.87	0.26	0.00	0.10	105.60	2.00	45.30

From Madison and Brunett's interpretation of nitrate levels about 90% of the values of nitrate in this work seem to suggest human influence as they seem to exceed the threshold of 3.0 mg/l. Moreover in certain wells nitrate values exceeded the WHO health standards of 45mg/l, about twenty percent (20%) of the samples gave these levels.

The nitrate elevated values where noticed to be predominant on the Jos Biotite granite rock type which happens to be the largest rock type within the most built up areas. This leads to the deduction that the high nitrate values could result from sewage, pit latrines, and refuse dumps.

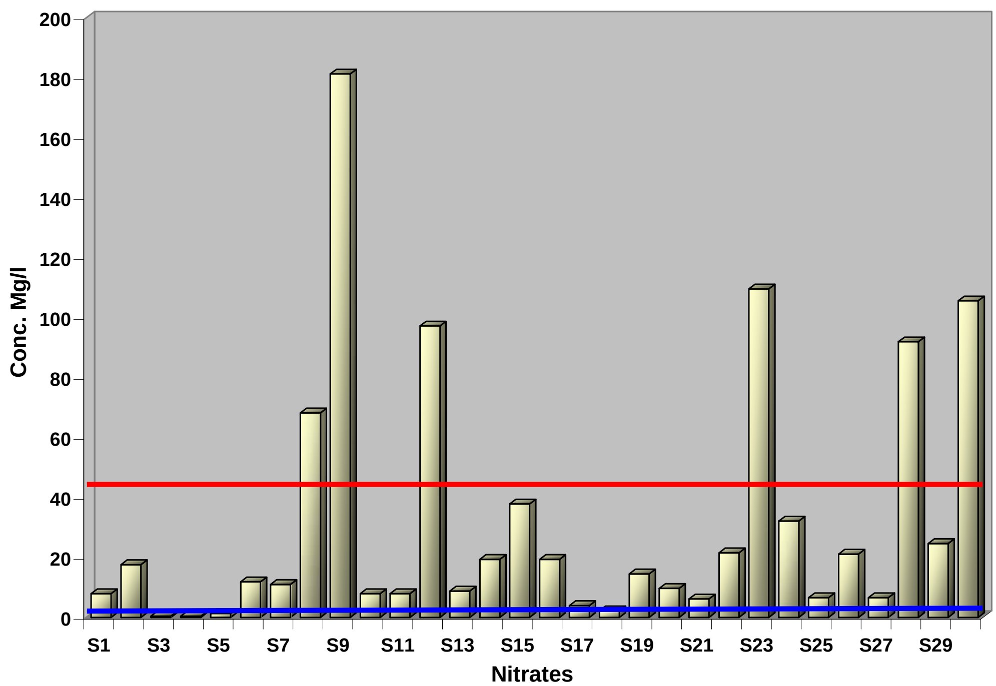
High nitrate concentrations in drinking water are associated with the development of methaemoglobinaemia in infants. This is a situation where nitrate is reduced to nitrite as nitrate itself does not cause this disorder. The nitrite combines with haemoglobin in red blood cells to form methaemoglobin, which is unable to carry oxygen and so reduces oxygen uptake in the lungs.

Normal methaemoglobin level in blood is between 0.5 and 2.0%. As methaemoglobin does not carry oxygen, excess levels lead to tissue anoxia (i.e. oxygen deprivation). It is only when the methaemoglobin concentration in the blood exceeds 10% that the skin takes on a blue tinge.

In infants, the disorder is known as methaemoglobinaemia or blue-baby syndrome. The progressive symptoms resulting from oxygen deprivation are stupor, coma, and eventual death. Death ensues when 45-65% of the haemoglobin has been converted. However the disorder can be readily treated using an intravenous injection of methylene blue, which results in rapid recovery (World Health Organization, 1984). Although methaemoglobinaemia is well recognized and is unlikely to be a problem in areas with adequate medical facilities, it may be more important in the developing areas where such facilities are lacking.

All the health considerations relating to nitrate are related to its conversion to nitrite. In the gastrointestinal tract, nitrite reacts with certain compounds in food under acidic conditions to produce *N*-nitroso compounds with amines and amides. Many of these compounds are known carcinogens. Although there is no epidemiological evidence to link nitrate directly with cancer in humans, increased concentrations of nitrite and N-*nitroso* compounds have been detected in people who secrete inadequate amounts of gastric acid, a group known to be particularly at risk from gastric cancer. (Gray, 1994, Forman et al., 1985).

pH: The pH of an aqueous system is a measure of the acid-base equilibrium achieved by various dissolved compounds and, in most natural waters, is controlled by the carbon dioxide-bicarbonate- carbonate equilibrium system. The pH of most raw water sources lies within the range of 6.5-8.5. pH and can be rightly referred to as the backbone of water quality parameters since almost every other water quality parameter is related to pH. Hence and examination of anomalous pH characteristics was conducted in the study area.



Indicating Contamination by Human Influence = 3.0mg/l

WHO Standard for Nitrate = 45mg/l

Figure 2: Concentration of Nitrates.

From Figure 3, low pH values (below the allowable minimum standard) in samples S 5, 8, 13, 14, 15, 16, 17, 18, 19, and 23 may be responsible for the spatial behavior of chloride.

Average Concentrations

Manganese: The quality for Concentrations of manganese in the samples where on the average, being widely found in rocks and like iron turns up in groundwater due to reducing conditions in soils and rocks bringing it into soluble form. Once it is exposed to air by aeration, manganese is oxidized into its insoluble form.

Manganese, like iron, causes problems of taste, discoloration, and staining. Gray (1994) notes that staining is far more severe with manganese than iron and it imparts an unacceptable taste to the water. For this reason much stricter limits have been imposed on the concentration at which laundry and sanitary ware become discolored to grey/black; MAC (PCV) limits it at 0.05 mg/l., while the EC guide level is just 0.02 mg/l.

The World Health Organization has a health-related guide of 0.5 mg/l, but since staining occurs at much lower concentrations, a guide value of 0.1 mg/l has been set to prevent consumer complaints. The concentration of manganese in the study area is averagely acceptable for health purposes as toxicity is not a factor with manganese, consumers would reject at concentrations long before any danger threshold is reached. However this is not true for laundry purposes as illustrated in the Figure 4.

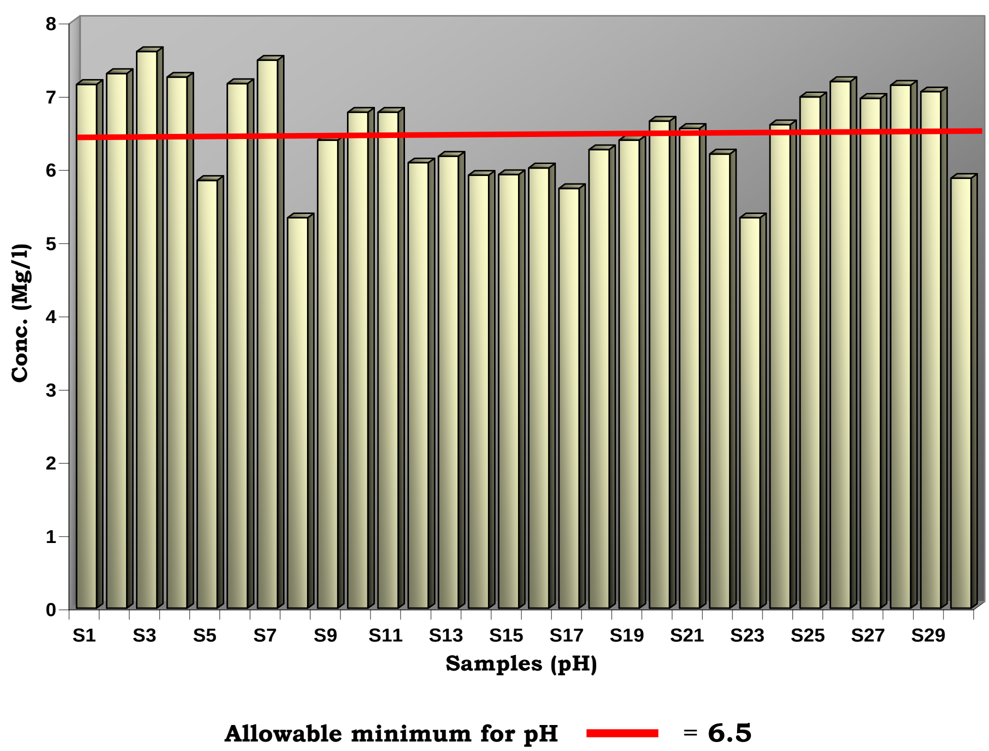


Figure 3: Concentration of pH in the Study Area.

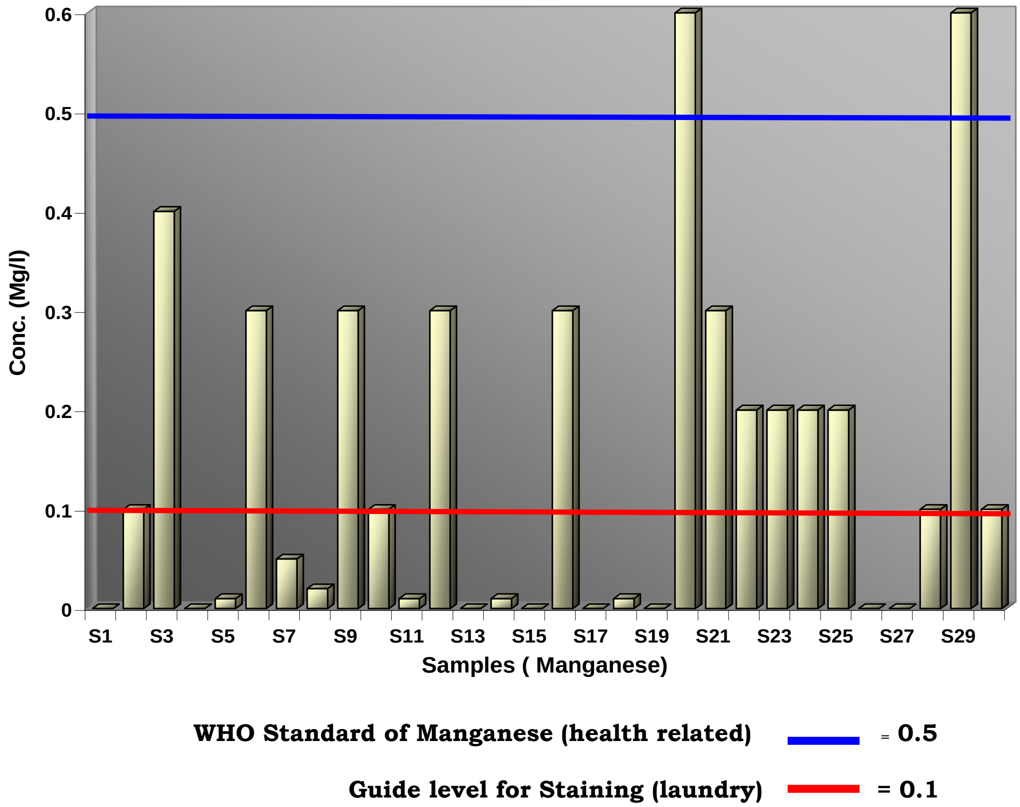


Figure 4: Various Concentrations of Manganese.

<u>Acceptable Concentrations</u>:

<u>Hardness</u>: Hardness or softness of water varies from place to place and reflects the nature of the geology of the area with which the water has been in contact. The principal metal cations causing hardness are Ca^{2+}, Mg^{2+}, Sr^{2+}, Fe^{2+}, and Mn^{2+},and the major anions associated with them are HCO_3^-, SO_4^{2-}, Cl^-, NO_3^-, and SiO_3^{2-}. Table 2 shows the classification of hardness from the work of Gray (1994) as applied to the data in this study presented in Figure 5.

The water in the study area is generally soft which is associated with impermeable rocks such as granite (Gray, 1994). Also parameters like Iron, Copper, Sulphate, Chloride, Magnesium, Calcium and TDS measure within the acceptable concentration range of the WHO acceptable limits.

Table 3: Classification use for Water Hardness.

Degree of Hardness	Conc. (Mg/l)
Soft	0-50
Moderately Soft	50-100
Slightly Hard	100-150
Moderately Hard	150-250
Hard	250-350
Excessively Hard	350+

Source: Gray, 1994

CONCLUSION

Nitrates have been identified with values well beyond the WHO standard and is therefore a risk to public health particularly infants. These results in this study could be used to structure a public health program that would take into cognizance this threat to human health in health care program planning.

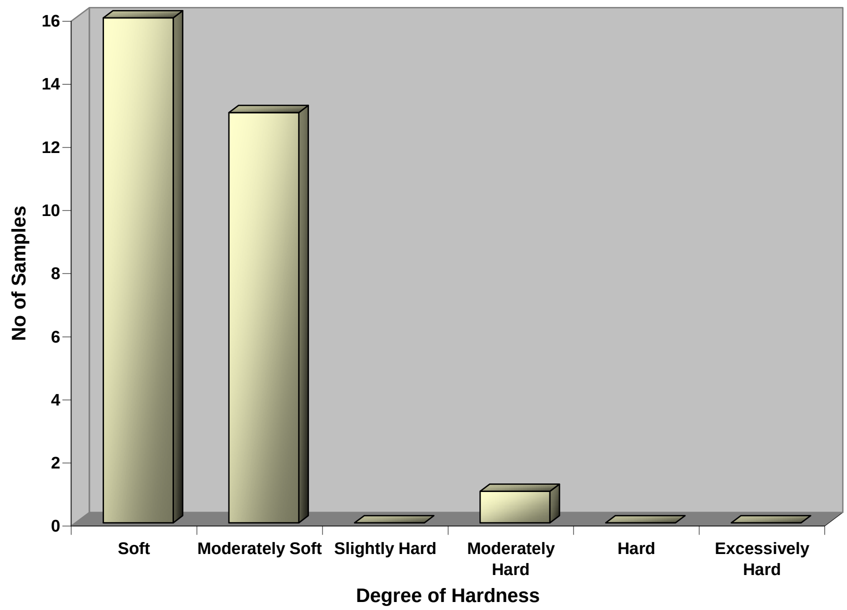


Figure 5: Classification of Water Quality in Terms of Hardness.

Another area in which the results of this study will find usefulness is the selection and siting of wells for the purposes of monitoring groundwater quality base on the places where some of these parameters measured above the WHO standard.

It is our contention that out of these monitoring programs; zoning of aquifers and protection of certain areas that have shown from continuous records that are vulnerable to pollution from certain contaminants. Therefore areas like the Jos Township which is the most populated area in the study area with high nitrate values ought to haves its sewage and refuse disposal system reassessed.

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