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PRELIMINARY INVESTIGATION OF THE CHEMICAL QUALITY OF DOMESTIC WATER SOURCES IN SELECTED COMMUNITIES OF LANGTANG AREA, PLATEAU STATE, NIGERIA

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ABSTRACT

A preliminary analysis of the chemical quality of domestic water sources in Langtang area was undertaken to determine variation in quality of water sources and how it meets the Nigerian Standard for Drinking Water Quality (NSDWQ). Using stratified random sampling technique, 50 water samples were taken from five different sources: rain, dams, streams, boreholes and hand dug-wells. Samples were tested in the laboratory for 20 parameters using standard methods described by USEPA (2012) and results subjected to ANOVA and independent sample t-tests. Temperature (28), turbidity (15), Ca (85), Mg (30), Cl (275), Fe (1.2), Pb (0.1) and Cd (0.002) had average mean above limits. ANOVA result shows significant variation in water quality with p-value of 0.001. Post-Hoc test revealed significant variation in 80% of the parameters tested: temperature, turbidity, EC, $CaCO_3$, F, TDS, Ca, Mg, NO_3, Fe, Cu, Al, Pb, As and Cd. Only pH, Cl, Mn, Cr and Zn do not show significant variation. Independent sample t-test also show significant variation in water quality to the Nigerian Standard for Drinking Water Quality (NSDWQ), which implies the water is unsuitable for human consumption. This study has demonstrated that despite differences in the protection levels of water sources, some parameters may still be the same across sources. It is therefore recommended that detail analysis of each water source be carried out to identify parameters responsible for pollution, as well as remediation the of water before consumption.

Keywords: Water Sources; Water Quality Variation; Water Safety

INTRODUCTION

Water is an essential natural resource that sustains human life but it is not free everywhere, and its chemical composition is the prime determinant of the suitability for human consumption. However, sequel to suspension of production at the Langtang Water Works in 2012 being the only public water supply scheme in the area, there is no any known monitoring effort in place to ensure the safety of drinking water sources in Langtang area. Besides, the area has low groundwater yield due to poor lithology and the effect of climate change that results in the drying of most surface water sources and seasonality of stream flow has exacerbated the situation thereby creating perennial water scarcity. So, residents access water from any available source that include; boreholes, hand dug-wells, dams, streams and rainwater harvesting.

Contaminants usually get into water sources through leaching from soil, rock weathering, run-off and aerosol dissolution from atmosphere (Saidu, et al., 2020; Ram et al., 2021). Unplanned waste disposal systems and unhealthy agricultural practices that involve heavy use of fertilizers and other agro-chemicals close to water points are common sites in the area, thereby exposing water sources to contamination. Katarzyna and Zdechlik (2021) has observed that just as the water sources and contaminant sources vary, the level of variables concentration may also show high variation from one water source to another. Studies (Musa, Adejumo, & Fumen, 2013; Nawab, et al, 2017; Toure, Wenbiao & Keita, 2017; Oliver et al., 2019; Kothari, Vij, Sharma &Gupta, 2020) have revealed variations in the concentrations of different water quality parameters and suitability of domestic water of different sources for human consumption in many parts of the world. Considering that all available water sources are used in the area due to acute scarcity especially during dry season, it became necessary that the levels of the individual parameter concentrations and its variation from one source to another be analysed. The results is expected to reveal how safe are the water sources in the area for human consumption and/or spark detail research towards identification of the specific risk associated with each water source where the results show significant variation from established standard. Therefore, the objective of this study is to analyse variation in the chemical concentrations of water quality variables among water sources in Langtang area as well as from the Nigerian Standard for Drinking Water Quality (NSDWQ).

METHODOLOGY

Study Area

The study area covers the whole geographic entity of Langtang North and South LGAs also referred to as Langtang area. The area is in the lowland part of Plateau State about 200 km south of Jos the State capital. Langtang area is located within latitudes $8^0$20'00" and $9^0$40'00" north and longitudes $9^0$30'00" and $10^0$10'00" east. It has a land mass of 1,626 sqkm and share boundaries with Kanke, Kanam, Pankshin, Mikang, Shendam LGAs and Taraba State (Figure 1). The area has sub-humid climate like the neighboring Taraba State with a mean low and high temperatures of 26^0C and 35^0C respectively. The mean low and high monthly rainfall are 5 mm and 50 mm respectively. While the wet season is usually from May to October, dry season is from November to April.

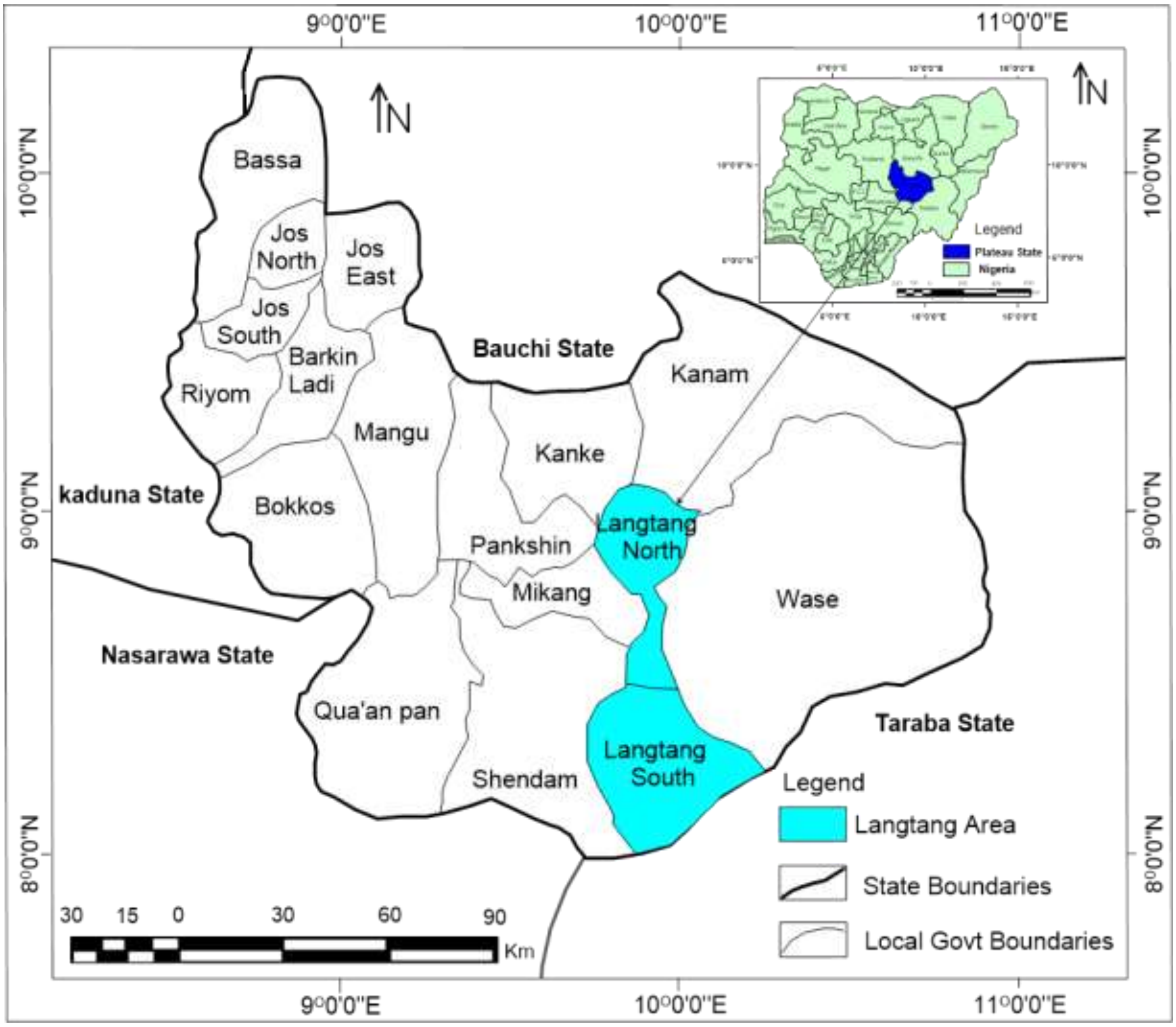

Figure 1: Plateau State showing Langtang Area (Insert Nigeria)

The relief is composed of uplands in the extreme north with average elevation of 500 above mean sea level (amsl) and lowlands in the southern part with average elevation of 150 amsl (Dibal et al., 2017). The original guinea savannah vegetation of the area has been replaced by a grassy savannah with occasional shrubs due to human interference through land clearance and burning for farming and firewood. This has resulted in regrown vegetation at various levels but the original woodland vegetation (gallery forest) is still found along major streams.

Geologically, Langtang falls within North-Central crystalline basement complex of Nigeria, and has five major geological units: biotite granite, migmatite granite, sandstone, shale/limestone intercalations, and sandy-clay/limestone. Based on FAO classification system, nine dominant soil types are found in the area namely: Vertisol, Gleysol, Leptosol, Acrisol, Lixisol, Nitisol, Alisol, Cambisol and Luvisol. Major drainages in the area are rivers Wase and Shemankar and their tributaries such as Pil-Gani, Bapkwai and Zamko with dendritic patterns. Settlements are rural with dispersed pattern and few nucleated. Groundwater has low yield due to lithology and most water sources either dry off or witness significant reduction in volume during drought and dry season leading to annual circle of severe water scarcity (Gongden & Lohdip, 2009)). Women and the girl child spend a better part of the day in search of water in some rural communities during dry season.

Water Sample Collection and Analysis

List of communities and available water sources in each was obtained from the Water and Sanitation Units at the Local Government Council's Secretariat of Langtang North and Langtang South that make up Langtang area. Coordinates of communities with a minimum of three water sources were taken and plotted on geological map of the area which has five major geological units; biotite granite, migmatite granite, sandsone, shale-limestone and Sandy-clay-limestone. The choice of communities with at least three water sources was to ease field work as well comparison of the quality of water within a particular area to aid decision on choice of water source that may offer cheaper treatment. Due to insufficient resources, time and man power, 10 out of the 40 communities having at least three water sources were selected for the study using a stratified random sampling technique. Two communities in each of the five geological units were selected randomly with the geological boundaries serving as strata. The random selection involved the use of a "lucky dip" with "yes" written on pieces of paper corresponding to the number of communities to be selected. All communities having three water sources and above in each stratum were dipped. Picking was done by the first author without replacement in which communities that picked "yes" were included in the sample. The 10 selected communities were: Pil-Gani, Gazum, Batkilang, Bapkwai, Zamko, Mabudi, Nassarawa, Magama, Faya and Barack.

Five water samples were taken from every community, one each from rain, hand dug-well, borehole, dam and stream. In communities with only three water sources, the fourth was picked from the nearest settlement within the same geological unit. Rainwater samples were collected directly into the sampling container from zinc catchment while raining in the month of September and labeled with samples code S1 to S10. Borehole samples were also collected directly into sample container after allowing the water to flow for two minutes to avoid collecting stagnant water in the pipe and labeled S11 to S20. A clean plastic bucket tied to a rope was used to collect water from hand dug-wells, then poured in sample container and labeled S21 to S30. Lastly, a plastic bowl was used to fetch water from dams and streams, then poured into sampling containers and labeled S31 to 40 and S41 to S50 respectively. Therefore, 50 water samples were collected and analysed. Sampling containers were rinsed thrice with the source water before it was filled up, and then capped and stored in field cooler with ice packs to avoid a rise in temperature that may affect the results. Names of sample location were recorded (Table 1), while coordinates of sample points taken with GPS plotted (Figure 2). Samples were moved to laboratory within 24hrs. Labile parameters such as pH, turbidity, temperature EC and TDS were determined in the field with the aid of hand held digital pH, Turbidity meter (Phep 98201), EC/TDS meter (Medfab 190), and a digital thermometer (CE 0434) for temperature. The Atomic absorption spectrophotometer (AAS) standard method was used for analysis of chemical parameters.

Data Analysis

Results of laboratory analysis of water samples were subjected to further analysis to provide meaning to the data using various analytical techniques. These include; measures of central tendency (mean), measures of dispersion (standard deviation), analysis of variance (ANOVA) and independent sample t-test. ANOVA, a parametric statistical technique is normally used to test variation in discrete data of more than two groups, and the Post-hoc test which undertakes multiple comparisons was used to determine variation in the concentration of individual water quality parameter when ANOVA result show significance. The independent sample t-test usually applied in testing variations in data of independent origin was used in analyzing variation in concentrations of water quality parameters and the published Nigerian Standard for Drinking Water Quality.

Table 1: Name and Co-ordinate of Sample Locations

Sample Code	Type of Water Point	Name of Settlement	Location Name	Latitude	Longitude
S1	Rainwater	Pil-Gani	Pil Roundabout	$09^{0}12^{1}12.7^{11}$	$009^{0}52^{1}21.6^{11}$
S2	Rainwater	Gazum	Ponhzi Zini house	$09^{0}14^{1}11.1^{11}$	$009^{0}45^{1}46.2^{11}$
S3	Rainwater	Bapkwai	GSS Bapkwai	$09^{0}4^{1}21.8^{11}$	$009^{0}48^{1}58.8^{11}$
S4	Rainwater	Batkilang	Batkilang Clinic	$09^{0}3^{1}6.4^{11}$	$009^{0}48^{1}14.5^{11}$
S5	Rainwater	Zamko	JUTH Zamko	$08^{0}58^{1}45.6^{11}$	$009^{0}48^{1}39.7^{11}$
S6	Rainwater	Mabudi	Ponzi house	$08^{0}44^{1}11.6^{11}$	$009^{0}47^{1}41.8^{11}$
S7	Rainwater	Nassarawa	Ciroma house	$08^{0}39^{1}42.7^{11}$	$009^{0}42^{1}19.5^{11}$
S8	Rainwater	Magama	Ubandoma house	$08^{0}29^{1}46.5^{11}$	$009^{0}44^{1}51.1^{11}$
S9	Rainwater	Faya	Nanchang house	$08^{0}34^{1}24.8^{11}$	$009^{0}55^{1}20.6^{11}$
S10	Rainwater	Barrack	Galadima house	$08^{0}24^{1}16.3^{11}$	$009^{0}51^{1}5.4^{11}$
S11	Borehole	Pil-Gani	Magistrate Court	$09^{0}12^{1}00.3^{11}$	$009^{0}53^{1}21.5^{11}$
S12	Borehole	Gazum	Gazum Market	$09^{0}13^{1}48.6^{11}$	$009^{0}46^{1}16.9^{11}$
S13	Borehole	Bapkwai	Gidan Dashe	$09^{0}4^{1}5.1^{11}$	$009^{0}49^{1}00.2^{11}$
S14	Borehole	Batkilang	Kofar Zamchir	$09^{0}3^{1}20.5^{11}$	$009^{0}48^{1}20.4^{11}$
S15	Borehole	Zamko	Gangara	$08^{0}59^{1}00.5^{11}$	$009^{0}48^{1}48.3^{11}$
S16	Borehole	Mabudi	LGC Secretariat	$08^{0}43^{1}50.3^{11}$	$009^{0}47^{1}57.5^{11}$
S17	Borehole	Nassarawa	Nassarawa Market	$08^{0}34^{11}\ 3.2^{11}$	$009^{0}42^{1}25.1^{11}$
S18	Borehole	Magama	Magama Market	$08^{0}29^{1}46.2^{11}$	$009^{0}43^{1}56.7^{11}$
S19	Borehole	Faya	Fumang	$08^{0}32^{1}42.9^{11}$	$009^{0}55^{1}13.4^{11}$
S20	Borehole	Timjul	Timjul	$08^{0}25^{1}53.3^{11}$	$009^{0}49^{1}59.5^{11}$
S21	Dug-well	Pil-Gani	Samjur	$09^{0}11^{1}48.3^{11}$	$009^{0}53^{1}3.4^{11}$
S22	Dug-well	Gazum	Kofar Mai Angwa	$09^{0}14^{1}17.1^{11}$	$009^{0}46^{1}23.4^{11}$
S23	Dug-well	Bapkwai	Kofar Mai Angwa	$09^{0}4^{1}19.2^{11}$	$009^{0}48^{1}37.4^{11}$
S24	Dug-well	Batkilang	Kapshe	$09^{0}2^{1}38.7^{11}$	$009^{0}48^{1}36.8^{11}$
S25	Dug-well	Zamko	Gargawa Junction	$08^{0}\ 59^{1}9.2^{11}$	$009^{0}48^{1}.48.4^{11}$
S26	Dug-well	Mabudi	WAYEP Hospital	$08^{0}\ 3^{1}57.6^{11}$	$009^{0}47^{1}30.5^{11}$
S27	Dug-well	Nassarawa	Gangara	$08^{0}34^{1}8.3^{11}$	$009^{0}42^{1}32.4^{11}$
S28	Dug-well	Bolgang	Bolgang	$08^{0}28^{1}39.5^{11}$	$009^{0}43^{1}36.7^{11}$
S29	Dug-well	Faya	Mr Gwomzi house	$08^{0}34^{1}10.3^{11}$	$009^{0}55^{1}45.7^{11}$
S30	Dug-well	Barrack	Kofar Qwag	$08^{0}24^{1}49.5^{11}$	$009^{0}50^{1}45.8^{11}$
S31	Dam	Dadur	Dadur Dam	$09^{0}13^{1}11.4^{11}$	$009^{0}49^{1}35.5^{11}$
S32	Pond	Gazum	Zamlir	$09^{0}13^{1}08.2^{11}$	$009^{01}14^{1}17.1^{11}$
S33	Dam	Langtang	Langtang Dam	$09^{0}8^{1}0.1^{11}$	$009^{0}48^{1}0.\ 7^{11}$
S34	Pond	Batkilang	Jan-Ruwa	$09^{0}3^{1}\ 22.2^{11}$	$009^{0}48^{1}4.8^{11}$
S35	Dam	Nagane	Nagane Dam	$08^{0}45^{1}25.9^{11}$	$009^{0}50^{1}36.2^{11}$
S36	Dam	Mabudi	Mabudi Dam	$08^{0}43^{1}44.1^{11}$	$009^{0}47^{1}39.\ 4^{11}$
S37	Dam	Karkashe	Karkashe Dam	$08^{0}33^{1}37.9^{11}$	$009^{0}42^{1}15.9^{11}$
S38	Dam	Magama	Magama Dam	$08^{0}29^{1}52.3^{11}$	$009^{0}43^{1}40.9^{11}$

S39	Dam	Faya	Faya Dam	08^{0}33^{1}53.7^{11}	009^{0}55^{1}39.1^{11}
S40	Pond	Barrack	Ruwan Zak	08^{0}24^{1}17.4^{11}	009^{0}50^{1}27.2^{11}
S41	Stream (SW)	Pil-Gani	R. Pil-Gani	09^{0}12^{1}32.4^{11}	009^{0}53^{1}23.4^{11}
S42	Stream (SW)	Gazum	R. Gazum	09^{0}14^{1}38.3^{11}	009^{0}46^{1}3.5^{11}
S43	Stream (SW)	Bapkwai	R. Bapkwai	09^{0}4^{1}7.3^{11}	009^{0}49^{1}46.9^{11}
S44	Stream (SW)	Batkilang	R. Batkilang	09^{0}2^{1}59.9^{11}	009^{0}48^{1}43.2^{11}
S45	Stream (SW)	Zamko	R. Zamko	08^{0}59^{1}1.4^{11}	009^{0}48^{1}13.9^{11}
S46	Stream (SW)	Sabon Gida	R. Sabon Gida	08^{0}43^{1}53.8^{11}	009^{0}42^{1}50.4^{11}
S47	Stream	Nassarawa	Nassarawa lake	08^{0}34^{1}14.3^{11}	009^{0}41^{1}0.7^{11}
S48	Stream	Magama	Magama Lake	08^{0}29^{1}47.5^{11}	009^{0}42^{1}59.7^{11}
S49	Stream	Faya	Kogin Yashi	08^{0}34^{1}3.8^{11}	009^{0}56^{1}46.3^{11}
S50	Stream	Barrack	Kogin Yashi	08^{0}24^{1}20.1^{11}	009^{0}51^{1}20.1^{11}

SW = Shallow Well

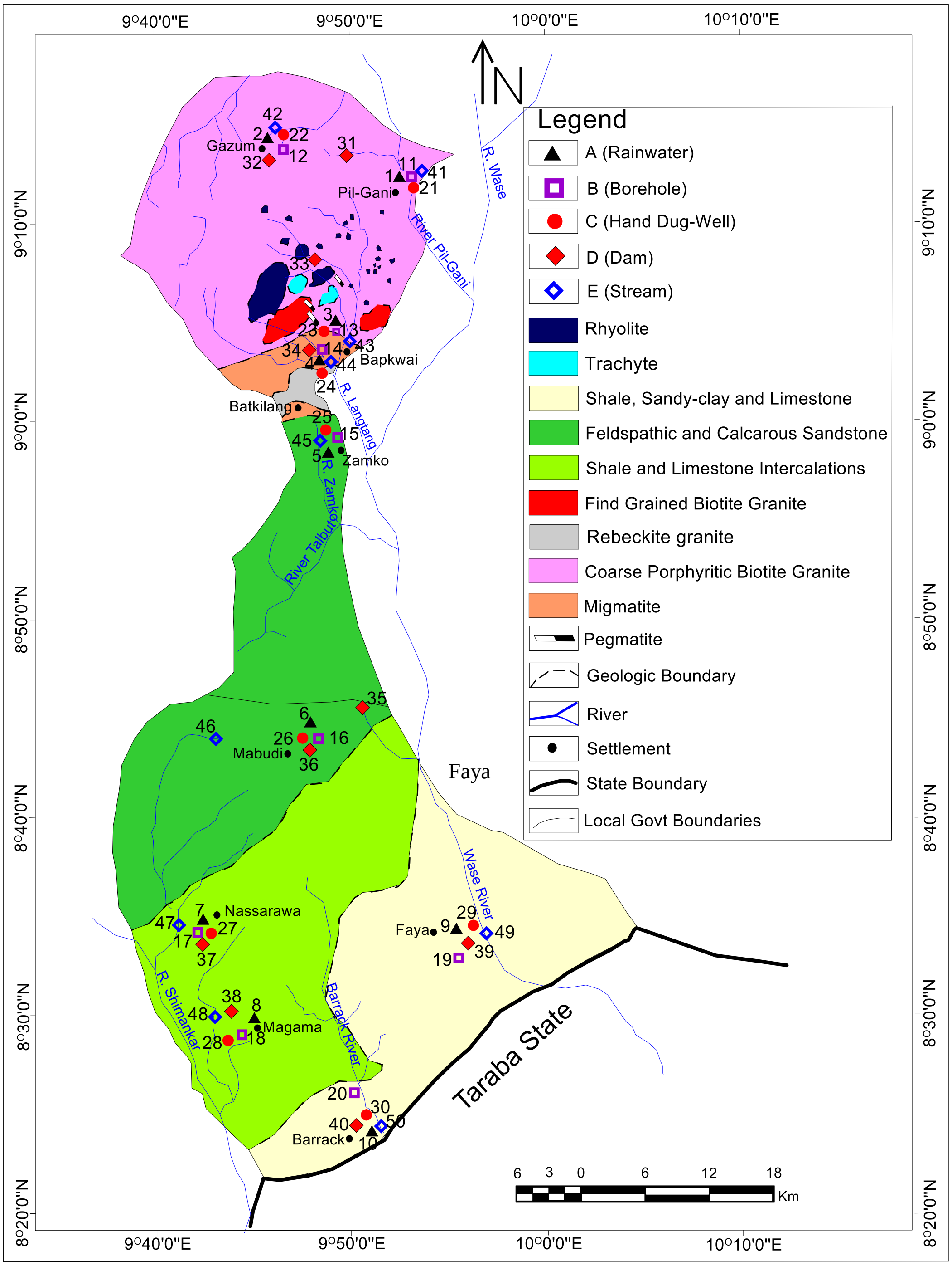

Figure 2: Geology, Selected Communities and Sample Points in Langtang Area

RESULT AND DISCUSSION

Variation in the Concentration of Physical and Chemical Parameters in Water Sources

Post-Hoc result of physical and chemical parameters of water samples is presented in Table 2.

Table 2: Variation in Physical and Chemical Parameters

Parameter	Water Source	N	Min	Max	Mean±STD	P-value	NSDWQ
Temperature	Rain	10	26.8	27.50	27.05±0.217		
	Borehole	10	28.1	29.10	28.48±0.469		
	Dug-well	10	27.7	29.10	28.59±0.438	0.000	25
	Stream	10	27.7	28.70	28.14±0.392		
	Dam	10	6.60	8.600	28.50±0.625		
Turbidity	Rain	10	1.80	5.000	2.550±0.932		
	Borehole	10	0.25	4.280	1.190±1.420		
	Dug-well	10	0.35	124.0	18.01±38.07	0.003	5
	Stream	10	2.50	97.00	27.50±34.60		
	Dam	10	4.00	112.0	45.37±31.30		
Conductivity	Rain	10	20.0	50.00	26.10±10.69		
	Borehole	10	280	2880	1128±938.1		
	Dug-well	10	16.0	1230	356.4±396.8	0.000	1000
	Stream	10	50.0	380.0	212.4±92.69		
	Dam	10	101	670.0	222.1±172.9		
pH	Rain	10	6.50	7.800	7.130±0.416		
	Borehole	10	7.00	7.500	7.270±0.142		
	Dug-well	10	6.30	8.400	7.210±0.545	0.835	6.5-8.5
	Stream	10	6.70	8.400	7.360±0.473		
	Dam	10	6.60	8.600	7.210±0.545		
TDS	Rain	10	10.0	25.00	13.50±5.297		
	Borehole	10	140	1440	567.7±475.1		
	Dug-well	10	30.0	615.0	214.6±176.8	0.000	500
	Stream	10	25.0	190.0	123.0±53.63		
	Dam	10	65.0	335.0	144.2±90.53		
Calcium	Rain	10	2.00	25.00	7.930±5.469		
	Borehole	10	105	237.0	143.9±43.38		
	Dug-well	10	44.0	364.0	142.3±86.84	0.000	75
	Stream	10	10.0	128.0	59.46±38.03		
	Dam	10	8.00	168.0	49.14±61.01		
Magnesium	Rain	10	1.00	4.000	2.000±1.155		
	Borehole	10	19.7	89.90	48.47±21.48		
	Dug-well	10	6.80	92.80	37.26±29.65	0.000	20
	Stream	10	3.00	39.80	15.64±10.81		
	Dam	10	2.00	72.50	13.99±21.51		
Hardness (Caco$_3$)	Rain	10	5.00	10.00	6.500±1.958		
	Borehole	10	120	498.0	317.0±143.8		
	Dug-well	10	55.0	508.0	199.6±128.4	0.000	150
	Stream	10	37.0	94.00	65.40±19.59		
	Dam	10	29.0	155.0	64.50±37.05		
Chloride	Rain	10	10.0	32.0	24.00±7.149		
	Borehole	10	2.60	50.0	512.00±8.274		
	Dug-well	10	0.20	28.0	722.00±8.495	0.054	250
	Stream	10	3.60	22.0	10.61± 5.327		
	Dam	10	0.00	144	37.70±47.820		
Nitrate	Rain	10	1.30	10.20	3.640±3.112		
	Borehole	10	5.50	45.20	26.98±13.86		
	Dug-well	10	5.00	83.00	48.20±24.62	0.000	50
	Stream	10	3.00	65.00	20.60±7.448		
	Dam	10	10.0	108.0	66.70±8.660		

Temperature and pH: Average temperatures of 27.05±0.217, 28.48±0.469, 28.59±0.438, 28.14±0.392 and 28.5±0.625 for rain, boreholes, hand dug-wells, streams and dams respectively were recorded and these vary significantly with p-value of 0.000. Both minimum and maximum temperatures of samples were above 25^0C recommended limit (WHO, 2011). This can be due to climatic influence and low gradient that retain heat. Though high temperature values are not harmful to health, it poses acceptability problem as values between 6^0C and 12^0C are more palatable to consumers (Degbey, et al., 2011). This result is similar to the work of Sorlini et al., (2013) in Logone Valley that revealed water temperatures was above the limits. The average pH for rain, boreholes, dug-wells, streams and dams were 7.13±0.416, 7.27±0.142, 7.21±0.545, 7.36±0.473 and7.21±0.545 in that order, and do not show significant variation with p-value of 0.0834. The pH of samples was within the 6.5-8.5 limits except for two hand dug-wells with pH of 6.3 which were attributed to dissolution from rocks.

Turbidity, TDS and Conductivity: Turbidity of water has no health effect but can shield micro-organisms and interfere with disinfections. Turbid water may also indicate microbes' presence. Mean turbidity of rain, borehole, dug-well, stream and dam were 2.55±0.932, 1.186±1.420, 18.01±38.072, 27.50±34.602 and 45.37±31.302 respectively with significant variation among sources. Turbidity of 30% samples mostly from surface water sources exceeded standard attributed to run-off and wind-blown objects. High TDS may results in displeasing colour, odour and taste. Minimum and maximum TDS of 10mg/l and 1440mg/l were recorded in rain and boreholes samples respectively. The average TDS for all water sources differs significantly from rain (13.5±5.297), borehole (567.7±475.13), dug-well (214.6±176.89), stream (123±53.632) to dam (144.2±90.534) at ($p<0.05$). Few groundwater samples had TDS above 500mg/l acceptable limit which was attributed to dissolution of minerals from rocks. Electrical conductivity is a measure of the capacity of solutions to conduct current and as also enable quantification of dissolved salt in water (Toure et al., 2017). Conductivity of water samples differs significantly from rain (26.1±10.692), borehole (1127.7±938.07), dug-well (356.4±396.75), stream (212.4±92.687) and dam (222.1±172.98). Only borehole has average EC above 1000mg/l recommended limit and this can due to rock dissolution. Most samples with high TDS also recorded high EC, which implies TDS influence conductivity.

Calcium, Magnesium and Hardness: Calcium is the most abundant alkaline earth metal in the crust, very mobile and usually found with magnesium. Its major source in water is from dissolution of salts from rocks of carbonate minerals like calcites and dolomites (Heston, 2015). Mean Calcium in rain, boreholes, hand dug-wells, streams and dams were 7.93±5.469, 143.9±43.38, 142.32±86.84, 59.46±38.03 and 49.14±61.01 respectively. Minimum Ca concentrations of 2 - 8mg/l were found in rain and stream samples, while maximum values of 237 - 364mg/l above 75mg/l limit were recorded in hand dug-well and borehole due to dissolutions from rocks. Similarly, Mg had means of 2.0±1.155, 48.47±21.48, 37.26±29.65, 15.64±10.81 and 13.99±21.51 for rain, boreholes, hand dug-wells, streams and dams in that order. While minimum values of 1-2mg/l were recorded in rain and dam samples, maximum values of 89.9 - 92.8mg/l were found in borehole and hand dug-well samples above the 20mg/l limit also attributed to rock dissolution. Groundwater had 75 and 85 percent Ca and Mg samples which could be responsible for the salty and hardness of groundwater sources in Langtang area.

The study revealed 38% of water samples are hard out of which 32% were from groundwater sources which reflects the influence of geology on water hardness in the area. Maximum values 508 - 498mg/l for hardness were recorded in hand dug-well and borehole respectively. Average hardness values were 6.5±1.958, 317±143.8, 199.6±128.4, 65.4±19.59 and 64.5±37.05 in rain, borehole, hand dug-well, stream and dam samples respectively. Post-hoc revealed significant variation in values of water hardness with a p-value of 0.000 (Table 2).

Nitrate and Chloride: Nitrates in water may be from inorganic fertilizer, leaching of wastewater, decomposed plants and animals or other organic waste, and above 50mg/l it causes blue baby syndrome in infants (Maseke & Vegi, 2019). The highest nitrate of 108mg/l as well as mean of 66.7±18.66 was all from dam samples and this was attributed to run-off, stagnation and decomposed plants. Chloride is an essential part of diet, less toxic to human but concern is related to frequent association of high chloride with elevated sodium levels (Illinois State Water Survey, 2018). Its natural sources include; NaCl, CaCl, KCl and MgCl, while anthropogenic are; road salt, human and animal wastes, water softeners and potash fertilizer (Jidauna et al., 2014). When above 250mg/l, chloride corrodes fixtures and impact salty taste to water (WHO, 2011). Mean chloride was above limits in boreholes (512±8.274) dug-wells (722±8.495) which could be responsible salty taste of groundwater of the area due to dissolution of salt rocks. Post-hoc result show significant variation in chloride concentration with p-value of 0.000.

Heavy Metals Variation in Water Sources

Fluoride and Copper: Fluoride levels was higher in 16% samples all from groundwater up to 5mg/l above 1.5mg/l acceptable limit in areas underlain by granites due to leaching from fluoride reach minerals. Fluoride consumption above 1.5mg/l results in dental and skeletal fluorosis (WHO, 2011). Mean fluoride levels in rain, borehole, dug-well, stream and dam vary significantly (Table 3). This result is similar to Dibal el al (2017) and Raju et al (2019) that reported high fluoride in groundwater in areas of basements due to dissolution from rocks in Langtang and India respectively.

Table 3: Variation of Heavy Metal Content in the water Sources

Parameter	Water Source	N	Max	Min	Mean±STD	P-value	NSDWQ
Iron	Rain	10	0.01	0.15	0.048±0.048	0.015	0.3
	Borehole	10	0.08	10.0	3.088±3.705		
	Dug-well	10	0.20	6.00	1.440±1.844		
	Stream	10	0.60	10.0	2.325±2.754		
	Dam	10	1.50	10.0	4.210±3.435		
Manganese	Rain	10	0.001	0.02	0.003±0.006	0.122	0.2
	Borehole	10	0.00	2.20	0.346±0.672		
	Dug-well	10	0.00	0.70	0.118±0.216		
	Stream	10	0.00	0.20	0.037±0.067		
	Dam	10	0.00	0.10	0.036±0.038		
Arsenic	Rain	10	0.00	0.00	0.000 ± 0.000	0.002	0.01
	Borehole	10	0.02	0.02	0.004±0.008		
	Dug-well	10	0.00	0.03	0.013±0.010		
	Stream	10	0.00	0.04	0.014±0.018		
	Dam	10	0.01	2.10	0.637±0.887		
Lead	Rain	10	0.00	0.001	0.0002±0.0004	0.038	0.01
	Borehole	10	0.01	1.01	0.147±0.309		
	Dug-well	10	0.00	0.30	0.067±0.103		
	Stream	10	0.00	1.40	0.164±0.435		

	Dam	10	0.00	2.10	0.554±0.736		
Aluminium	Rain	10	0.01	0.06	0.031±0.015		
	Borehole	10	0.00	0.10	0.025±0.037		
	Dug-well	10	0.00	0.40	0.105±0.128	0.023	0.2
	Stream	10	0.00	0.80	0.095±0.248		
	Dam	10	0.00	2.03	0.465±0.673		
Cadmium	Rain	10	0.00	0.001	0.001±0.001		
	Borehole	10	0.00	0.003	0.001±0.001		
	Dug-well	10	0.00	0.005	0.021±0.063	0.000	0.003
	Stream	10	0.00	0.09	0.024±0.054		
	Dam	10	0.002	1.90	0.632±0.679		
Chromium	Rain	10	0.01	0.05	0.027±0.025		
	Borehole	10	0.00	0.04	0.018±0.030		
	Dug-well	10	0.00	0.02	0.003±0.006	0.098	0.05
	Stream	10	0.00	0.02	0.003±0.006		
	Dam	10	0.002	0.21	0.037±0.061		
Fluoride	Rain	10	0.001	0.002	0.001±0.001		
	Borehole	10	0.70	5.80	1.850±1.854		
	Dug-well	10	0.41	4.20	1.540±1.229	0.000	1.5
	Stream	10	0.03	0.09	0.057±0.025		
	Dam	10	0.06	1.30	0.529±0.501		
Copper	Rain	10	0.01	0.70	0.143±0.218		
	Borehole	10	0.02	1.08	0.304±0.393		
	Dug-well	10	0.05	1.30	0.445±0.474	0.000	1.0
	Stream	10	0.20	2.40	0.527±0.704		
	Dam	10	0.95	2.92	1.871±0.722		
Zinc	Rain	10	0.00	1.45	0.376±0.588		
	Borehole	10	0.00	1.40	0.177±0.431		
	Dug-well	10	0.00	0.30	0.061±0.092	0.438	3
	Stream	10	0.00	0.66	0.124±0.250		
	Dam	10	0.00	1.07	0.181±0.348		

The human body has natural mechanism for maintaining the proper copper level usually developed after a year of birth. Therefore infants are more vulnerable to the toxic effects of copper. Though essential element, copper above 1mg/l results in anemia, liver, kidney and brain damages, gastrointestinal effect and elicits nausea (Toure et al, 2017). Mean copper was within limit in all water sources except dam which has 1.871±0.722, and Post-hoc result show significant variation in copper in water sources with p-value of 0.000 (Table 3). This is similar to Gongden and Lohdip (2015) that reported copper above limits in Mabudi and Nagane dams.

Iron and Zinc: Iron aid fluid circulation and transport of oxygen in the blood but excess iron interferes with fluid regulation, impact reddish color, and metallic taste. It also causes stains in laundry and fixtures (WHO, 2011). Iron ranged from 0.01-10.0mg/l with 70% samples above limits. Mean iron in rain, borehole, dug-well, stream and dam were: 0.048±0.048, 3.088±3.05, 1.44±1.844, 2.325±2.754 and 4.21±3.435 respectively (Table 3). Although zinc is necessary for humans and among least toxic metals with frequent serious deficiency problems than toxicity, continues ingestion of excess zinc can cause emesis (Gagnon et al, 2017). Both maximum and minimum concentrations of 1.45 and 0.3 were within 3mg/l acceptable limit. Post-hoc result shows no significantly variation in zinc concentration with - value of 0.438 (Table 3).

Aluminum and Manganese: Aluminium ranged from 0-2.03mg/l with six samples, four from dams (31, 32, 35 & 36) and two from stream (47 & 48) having aluminiuum concentration above limit of 0.2mg/l. Mean aluminiuun was within limit in all water sources except dam with 0.465±0.673 and it varies significantly in water sources with p-value of 0.001 (Table 4). The high aluminium in only surface suggest contaminant may from domestic waste containing aluminium product. Gongden and Lohdip (2015) had earlier reported Al up 3.5mg/l in Mabudi dam. Manganese thiugh an essential element but above 0.2mg/l, it impacts colour and taste to water and causes neurological disorder (SON, 2015). Mean Mn levels was within limits in the rain, stream, dam and hand dug-well water but above in borehole attributed to Mn weathering in deep groundwater (Table 3).

Arsenic and Lead: Arsenic and lead are both carcinogenic above 0.01mg/l (SON, 2015). The greatest threat to public health from As is from groundwater based on geological history with high risk in sedimentary than igneous rocks. Consumption of high As poses risk of skin, lungs, bladder and kidney cancers, hypertension, diabetes and peripheral vascular disease (Ayer et al, 2017). Arsenic ranged from below detection to 2.1mg/l and 36% samples contaminated were from dams, rivers and ponds suggesting anthropogenic sources. Lar et al (2014) have also reported As above limits in surface water in part of Langtang LGA. Mean As concentration was within acceptable limits but vary significantly among water sources with p-value of 0.002. Lead ranged below detection to 0.18, and above limit in 50% samples. Generally Pb get into water from soil and geogenic or anthropogenc sources such as batteries, paints, gasoline and pesticides (Khan et al, 2010). High lead causes social disorder, memory weakness and anemia (Nawab, et al, 2017). Contaminated samples were from surface water and open wells which suggest the influence of anthropogenic activities. This result is similar to Kabunga et al (2013), and Lar et al (2014) in Zambia and the study area respectively Mean Pb vary significantly in the area (Table 3).

Cadmium and Chromium: Cadmium ranged from below detection to 1.9mg/l with 0.129mg/l average. Means of

0.0006±0.0005, 0.0007±0.0011, 0.0021±0.063, 0.0242±0.054, 0.632±0.679 was recorded in rain, borehole, dug-well, stream and dam respectively with significant variation (Table 3). Average Cd in streams and dams were above limits due to bush burning for agriculture, use of fertilizer and discarded Cd containing products in the environment which may have find it's into surface water sources through run-off. This result is similar to Gongden and Lohdip (2015) had reported Cd of up to 2.0mg/l in Mabudi and Wubang dams as well as in Lagos Lgoon and Kampani River (Arimieari, et al,, 2014; Lawal, et al, 2014). Chromium also ranged from below detection level to 0.21 but mean of all water sources were within limits and show no significant variation with p-value of 0.098 (Table 3). Only Nagane dam and Barack dug-well had Cr above the 0.003mg/l acceptable which is likely due to oxidation of Cr alloys and agricultural contaminants that find its way into these water sources. Chromium remedy impaired carbohydrate metabolism by increasing insulin effectiveness but causes painless perforation of the nasal septum, malignant growth in respiratory tract, dermatitis and cancers of the lungs above limit (Zhitkovich, 2018; Shah, et al, 2012). Products containing Cr such as stainless steels are resistant to corrosion but slow oxidation of these alloys can release Cr into soil and water (Zhitkovich, 2018).

Variation in Langtang Area Water Quality from NSDWQ

An independent sample T-test was conducted to test variation in the concentration in water quality parameters of domestic water sources from NSDWQ. The result in Table 4 shows (48, -1.046, P = 0.031) statistically significant difference at 0.05 level of significance. This result has revealed that either all or significant percentage of the water samples analysed are not fit for human consumption because differences in concentration of water quality parameters from the standard usually occur due to pollution. This result is in agreement with Oliver et al., (2019) that reported significant variation in water quality parameters of boreholes, streams, dug-wells and lakes from NSDWQ in seven selected rural communities of Obioma Ngwa LGA, Abia State.

Table 4: Independent Sample T-Test for Variation in Concentration of Water Quality Parameters from Nigerian Stanard for Drinking Water Quality in Langtang Area (2018)

Group	N	$\overline{X}$	S.D	DF	TC	P-value
Experimental	25	37.32	88.43	48	-1.046	0.031
Standard	25	86.99	220.28			

SUMMARY AND CONCLUSION

Fifty water samples from five different sources were analyzed using standard methods for 20 variables. Viz: temperature, conductivity, turbidity, hardness, F, TDS, Ca, Mg, SO_4, NO_3, Cl, Fe, Cu, Al, Pb, As, Cd, Mn, Cr, Zn. Laboratory results of the samples analysed show heavy metal contamination was more in the surface water due to run-off, unplanned waste disposal system, stagnation and decomposition of waste materials, while contamination of the groundwater was more from salt rocks and other parameters that impact unpleasant taste are rejected by consumers. Results of inferential statistical analyses revealed significant variations in the concentration of variables among water sources and NSDWQ. Based on these findings, detailed analysis of each of the water sources to determine specific risk and recommend appropriate and effective water treatment methods is recommended.

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