POLLUTION LOAD AND HEALTH RISK INDICES OF DOMESTIC WATER SOURCES IN SELECTED COMMUNITIES OF LANGTANG AREA, PLATEAU STATE, NORTH-CENTRAL NIGERIA

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Abstract
Potential health risk of metals in domestic water sources to the local population of Langtang area in Plateau State and their possible sources was investigated. Forty water samples, 20 each from surface and groundwater sources were analysed using Atomic Absorption Spectrometer method for 26 parameters and compared with the Nigerian Standard for Drinking Water Quality. Results revealed that turbidity, Fe, Zn, As, Cd, Pb, Mn, Al, pesticides and phenols seriously polluted, while coliform bacteria strongly polluted in surface water. In groundwater, only turbidity, Fe, Pb and phenols constituted serious pollutants, while Ca and Mg were strong pollutants. Chronic Daily Intakes (CDIs) of metals were in the following order; Fe > Cu > Pb >As > Cd > F > Al >Mn >Zn > Pesticides >Cr > phenols in surface water, and Fe >F >Cu >Zn >Pb >Al >Mn >Cr >As >pesticides >phenols >Cd in groundwater. Health Risk Indices (HRIs) of metals were present in the order of As >Cd >Pb >Al >Cu >Mn >Fe >Cr >Zn >F >phenols >pesticides in surface water, and Pb >F >Al >Fe >As >Cr >Zn >Mn >Cd >phenols >pesticides in groundwater. Cumulative HRIs of metals was above unity in both surface and groundwater. Metals that pose most serious risk were; As, Cd, Pb and Al with HR of 33.32, 9.84, 2.75 and 2.14, all in surface water sources. Findings showed that the domestic water sources of the selected communities in Langtang area were not safe for human consumption. It is recommended that alternative drinking water source be provided to residents by government to safeguard public health.

Keywords: Drinking water quality, Pollution index, Health risk index

INTRODUCTION

Water is an essential natural resource that sustains human life but it is not free everywhere. Its chemical composition is the prime determinant of the suitability for use. Following suspension of production at the Langtang Water Works in 2012, the only public water supply scheme in the area due to obsolete equipment and poor power supply, residents access water from any available source including: dams, boreholes, dug-wells, streams and ponds. Water is abstracted from these sources are used for domestic purposes including drinking without treatment. Besides, indiscriminate waste disposal, open defecation and unhealthy agricultural practices which involved extensive use of agro-chemicals that expose water sources to contamination are common sites in the area. Contaminants may also get into water sources through leaching from soils, rocks weathering and aerosol dissolution from the atmospheres (Jidauna, Dabi, Saidu, Abaje & Ndabula, 2013).

Although some heavy metals like Cr, Mn and Cu are essential to man, their presence in excess above certain limits are toxic (Masok, Masiteng, Mavunda & Maleka, 2018). In contrast, metals such as Cd, Pb, Hg and As have no known benefit and are highly toxic at low concentration (Saha, Rahman, Jolly, Rahman, Sattar & Hai, 2016). These metals enter the human body through several pathways including food chain, water ingestion, dermal contact, fume and particles inhalation through mouth and nose (USEPA, 2016). The health risk indices is a useful method in determining the risk posed by these metals and has been applied by researchers to assess potential adverse health effects of exposure to contaminated water in parts of the world (Giri & Sign, 2015; Maigari, Ekanem, Garba, Harami, & Akan, 2016; Lorestani, Merrikhpour & Cheraghi, 2020). There is growing concern on the presence of toxic metals in drinking water and rural areas of developing countries have received the least attention in their health risk assessment. This becomes necessary to expand research to cover the rural communities especially Langtang area where untreated water is consumed. Studies have established that safe water is indispensable for prevention of diseases and improving quality of life (Jidauna, Dabi, Saidu, Abaje & Ndabula, 2014; Maina & Eziashi, 2017)). Therefore, this paper assesses the pollution levels of water quality parameters and determines health risk posed to human through oral ingestion of metals in drinking water.

The health risk assessment is a key element in appraising safety state of environmental resources which aid decisions on policy formulation, and its objective is to assess fitness of a resource for current and future use. This requires data on human health in a medium, estimation of magnitude of potential human exposure, toxicity assessment and characterization of risk (Lai, Hseu, Chen, Chen, Guno & Chen, 2010). Greater weights are also given to specific exposure estimates parameters such as concentration or level, duration, route and exposure frequency (UEEPA, 2012). Human exposure to metals is negligible through other pathways like dermis and inhalation in comparison to oral ingestion (Nawab, Khan, Xiaopinga, Rahman, Ali, Qamar, Khan, Rehman, Rahman, Muhammad, Khan& Shah, 2017). This informed the choice of the oral pathway being the major route that heavy metals find its way into the human body other than dermal for the determination of human health risk through water.

MATERIAL AND METHOD

Study Area

Langtang area consists of two LGAS, Langtang North and Langtang South. It is located in the lowland part of Plateau State 200km south of Jos the State capital and falls within latitudes $8^0$20'00"and $9^0$40'00" N and longitudes $9^0$30'00" and $10^0$10'00" E. It occupies a land mass of 1,626 sqkm and share boundaries with Kanke, Kanam, Pankshin, Mikang and Shendam LGAs as well as Nassarawa and Taraba States (Figure 1). It is characterized by sub-humid climate as neighboring Nassarawa and Taraba States due to similarities in elevation. The mean low and high temperatures are 26^0C and 30^0C respectively. The average monthly and annual relative humidity is between 20^0 and 28^0 with March and April as hottest months. Mean high and low monthly rainfall range between 5mm and 50mm, while Mean annual rainfall in the area is between 165 and 322.

The relief is composed of uplands and lowlands created by interplay of tectonic elevation and erosion intensified by deforestation and deep differential chemical rock weathering (Dibal, Schoeneich, Lar, Garba, Lekmang & Daspan, 2017). The uplands in the extreme north-west of Langtang North with average elevation of 500 amsl are made of hills, mountains, and undulating terrains. The lowland cover a part of Langtang North and the whole Langtang South, have an average elevation of 150 amsl, and is characterized by plain land with pockets of outcrops of basement complex rocks and isolated hills. 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. The people are predominantly peasant farmers living in rural settings with dispersed and few nucleated patterns.

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.

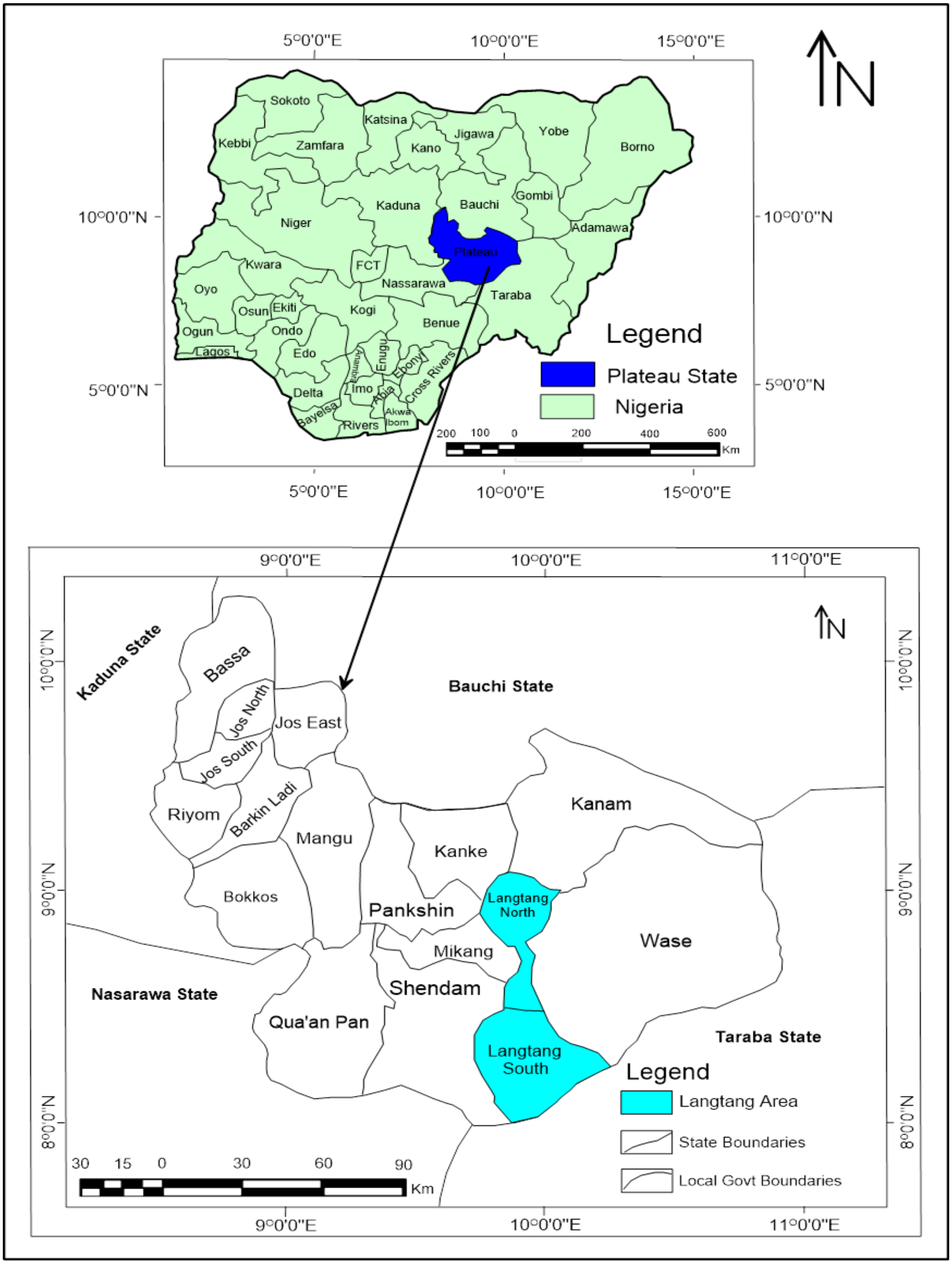

Figure 1 Plateau State; Study Area (Insert Nigeria and Plateau)

Data Collection

Samples are collected because the phenomena been studied are infinite, too large or due to limited resources (Saidu, Jidauna, Sanusi & Dabi 2019). Therefore, due to insufficient fund and time, 10 out of 46 communities were selected for this study based on water availability. A list of communities and available water sources in each was obtained from the Water and Sanitation Units at the Local Government Council secretariat of Langtang North and South. Coordinates of communities with 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. Thereafter, two communities in each of the five geological units were selected using a stratified random sampling technique 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 (Figure 2).

Four water samples were taken from every community, one each from dug-well, borehole, dam and stream. In the communities with only three water sources, the fourth was picked from the nearest settlement within the same geological unit. The polyethylene plastic bottles (1000ml) used for sample collection were sterilized. Borehole samples were collected directly into sample container after allowing the water to flow for two minutes to avoid collecting stagnant water in the pipe and labeled S1 to S10. A clean plastic bucket tied to a rope was used to collect water from dug-wells, then poured in sample container and labeled S11 to S20. Lastly, a plastic bowl was used to fetch water from dams and streams, then poured into sampling containers and labeled S21 to 30 and S31 to S40 respectively. Sampling containers were rinsed thrice with the source water before it is filled up, and then capped and stored in field cooler with ice packs to avoid a rise in temperature that may affect result.

Names and coordinates of sample locations were taken (Table 1). 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.

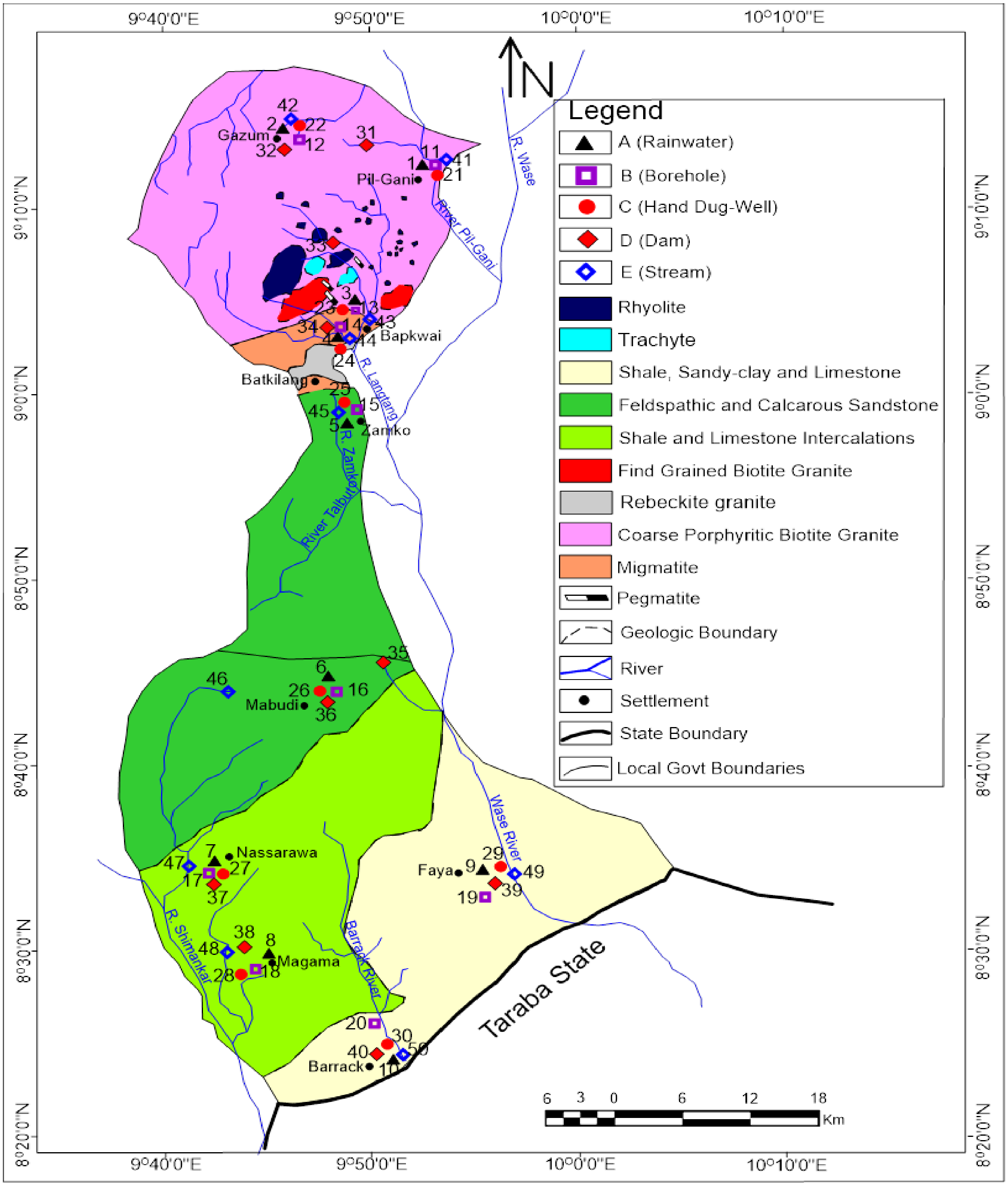

Figure 2 Geology of Selected Communities and Sample Points in Langtang Area

Table 1 Name and co-ordinate of sample locations

Sample Code	Type of Water Point	Name of Settlement	Location Name	Latitude	Longitude
S1	Borehole	Pil-Gani	Magistrate Court	$09^{0}12^{1}00.3^{11}$	$009^{0}53^{1}21.5^{11}$
S2	Borehole	Gazum	Gazum Market	$09^{0}13^{1}48.6^{11}$	$009^{0}46^{1}16.9^{11}$
S3	Borehole	Bapkwai	Gidan Dashe	$09^{0}4^{1}5.1^{11}$	$009^{0}49^{1}00.2^{11}$
S4	Borehole	Batkilang	Kofar Zamchir	$09^{0}3^{1}20.5^{11}$	$009^{0}48^{1}20.4^{11}$
S5	Borehole	Zamko	Gangara	$08^{0}59^{1}00.5^{11}$	$009^{0}48^{1}48.3^{11}$
S6	Borehole	Mabudi	LGC Secretariat	$08^{0}43^{1}50.3^{11}$	$009^{0}47^{1}57.5^{11}$
S7	Borehole	Nassarawa	Nassarawa Market	$08^{0}34^{11}$ 3.2^{11}	$009^{0}42^{1}25.1^{11}$
S8	Borehole	Magama	Magama Market	$08^{0}29^{1}46.2^{11}$	$009^{0}43^{1}56.7^{11}$
S9	Borehole	Faya	Fumang	$08^{0}32^{1}42.9^{11}$	$009^{0}55^{1}13.4^{11}$
S10	Borehole	Timjul	Timjul	$08^{0}25^{1}53.3^{11}$	$009^{0}49^{1}59.5^{11}$
S11	Dug-well	Pil-Gani	Samjur	$09^{0}11^{1}48.3^{11}$	$009^{0}53^{1}3.4^{11}$
S12	Dug-well	Gazum	Kofar Mai Angwa	$09^{0}14^{1}17.1^{11}$	$009^{0}46^{1}23.4^{11}$
S13	Dug-well	Bapkwai	Kofar Mai Angwa	$09^{0}4^{1}19.2^{11}$	$009^{0}48^{1}37.4^{11}$
S14	Dug-well	Batkilang	Kapshe	$09^{0}2^{1}38.7^{11}$	$009^{0}48^{1}36.8^{11}$
S15	Dug-well	Zamko	Gargawa Junction	08^{0} $59^{1}9.2^{11}$	$009^{0}48^{1}.48.4^{11}$
S16	Dug-well	Mabudi	WAYEP Hospital	08^{0} $3^{1}57.6^{11}$	$009^{0}47^{1}30.5^{11}$
S17	Dug-well	Nassarawa	Gangara	$08^{0}34^{1}8.3^{11}$	$009^{0}42^{1}32.4^{11}$
S18	Dug-well	Bolgang	Bolgang	$08^{0}28^{1}39.5^{11}$	$009^{0}43^{1}36.7^{11}$
S19	Dug-well	Faya	Mr Gwomzi house	$08^{0}34^{1}10.3^{11}$	$009^{0}55^{1}45.7^{11}$
S20	Dug-well	Barrack	Kofar Qwag	$08^{0}24^{1}49.5^{11}$	$009^{0}50^{1}45.8^{11}$
S21	Dam	Dadur	Dadur Dam	$09^{0}13^{1}11.4^{11}$	$009^{0}49^{1}35.5^{11}$
S22	Pond	Gazum	Zamlir	$09^{0}13^{1}08.2^{11}$	$009^{01}14^{1}17.1^{11}$
S23	Dam	Langtang	Langtang Dam	$09^{0}8^{1}0.1^{11}$	$009^{0}48^{1}0.\ 7^{11}$
S24	Pond	Batkilang	Jan-Ruwa	$09^{0}3^{1}$ 22.2^{11}	$009^{0}48^{1}4.8^{11}$
S25	Dam	Nagane	Nagane Dam	$08^{0}45^{1}25.9^{11}$	$009^{0}50^{1}36.2^{11}$
S26	Dam	Mabudi	Mabudi Dam	$08^{0}43^{1}44.1^{11}$	$009^{0}47^{1}39.\ 4^{11}$
S27	Dam	Karkashe	Karkashe Dam	$08^{0}33^{1}37.9^{11}$	$009^{0}42^{1}15.9^{11}$
S28	Dam	Magama	Magama Dam	$08^{0}29^{1}52.3^{11}$	$009^{0}43^{1}40.9^{11}$
S29	Dam	Faya	Faya Dam	$08^{0}33^{1}53.7^{11}$	$009^{0}55^{1}39.1^{11}$
S30	Pond	Barrack	Ruwan Zak	$08^{0}24^{1}17.4^{11}$	$009^{0}50^{1}27.2^{11}$
S31	Stream (SW)	Pil-Gani	R. Pil-Gani	$09^{0}12^{1}32.4^{11}$	$009^{0}53^{1}23.4^{11}$
S32	Stream (SW)	Gazum	R. Gazum	$09^{0}14^{1}38.3^{11}$	$009^{0}46^{1}3.5^{11}$
S33	Stream (SW)	Bapkwai	River Bapkwai	$09^{0}4^{1}7.3^{11}$	$009^{0}49^{1}46.9^{11}$
S34	Stream (SW)	Batkilang	River Batkilang	$09^{0}2^{1}59.9^{11}$	$009^{0}48^{1}43.2^{11}$
S35	Stream (SW)	Zamko	River Zamko	$08^{0}59^{1}1.4^{11}$	$009^{0}48^{1}13.9^{11}$
S36	Stream (SW)	Sabon Gida	River Sabon Gida	$08^{0}43^{1}53.8^{11}$	$009^{0}42^{1}50.4^{11}$
S37	Stream	Nassarawa	Nassarawa lake	$08^{0}34^{1}14.3^{11}$	$009^{0}41^{1}0.7^{11}$
S38	Stream	Magama	Magama Lake	$08^{0}29^{1}47.5^{11}$	$009^{0}42^{1}59.7^{11}$
S39	Stream	Faya	Kogin Yashi	$08^{0}34^{1}3.8^{11}$	$009^{0}56^{1}46.3^{11}$
S40	Stream	Barrack	Kogin Yashi	$08^{0}24^{1}20.1^{11}$	$009^{0}51^{1}20.1^{11}$

SW = Shallow Well

Determination of Pollution Load Indices

The Pollution Load Index (PLI) is a mathematical approach used to identify water quality impurities. It measures how polluted a water body or sample is at a certain location and time or the degree of its contamination. This approach identifies individual parameters responsible for water pollution in an area, source or body, and aid in providing focus to water quality managers to develop treatment or management techniques in line with the identified impurities (Abbasi

& Abbasi, 2012). PI was calculated according to equation (I) adopted from Amadi, Okunlola, Dan-Hassan, Aminu & Ola (2015). Thus:

$$PLI = \sqrt{(\frac{ci}{si})\max + (\frac{ci}{si})\min/2} \quad (1)$$

Where Ci is maximum and minimum values of monitored parameters and Si is the recommended standard for each variable. Pollution levels of parameters were grouped into five classes from I to V according template in Table 2 adopted from Amadi et al (2015) and Hefni (2016).

Table 2 Template for parameter classification based on pli values

I	<1	Not polluted
II	1 - 2	Slightly polluted
III	2 – 3	Moderately polluted
IV	3 – 5	Strongly polluted
V	>5	Seriously polluted

Determination of Health Risk Indices

The primary human health indicators in risk assessments are chronic dose intakes (CDIs) and Health Risk Indices (HRIs), and CDI is an input for calculation of HRI (Khan, Lu, Khan, Zakir, Khan, Khan, Wei & Wang , 2013). This is because assessing metals risk in water requires data on the metals concentrations and the quantity of water consumed for specified period. The CDI was calculated according to equation (II) adopted from Khan et al (2013). Thus:

$CDI = C_m D_m / B_w$ (2)

Where: C_m, D_w, and B_w refers to metal concentration, daily water intake and body weight respectively.

The daily intake of drinking water for adults is 2L/day and 1L/ day for children, while 72 and 32.7kg is body weight for adults and children respectively. The oral Toxicity Reference Dose (RfD), an estimate of continuous consumption of a certain quantity of water by human population including sensitive sub-groups like children likely to be without an appreciable risk of deleterious effects during a lifetime has been determined for various variables (USEPA, 2012; Wu, Zhao, Jia, Zhang, Zhang, Cheng, 2009). RfD for non-carcinogenic risk were taken from the database in the Integrated Risk Information System, which is built by USEPA (2005). The HRIs for non-carcinogenic risk in humans was calculated according equation (III) adopted from Shah, Ara, Muhammad, Khan and Tariq (2012). Viz: HRI = CDI/ RfD . . . Equ (III). Where, RfD is oral toxicity reference dose and CDI is chronic daily intake. When HRI values are less than unity (HRI < 1), then the vulnerable population is deliberated to be safe but when it's greater than unity (HRI>1), the population is said to be at risk of contracting diseases (Khan et al, 2013; Liu & Ma, 2020).

RESULTS AND DISCUSSION

Drinking Water Contaminants

The computed PLIs of surface and groundwater sources in Table 3 show water sources with turbidity, Fe, Zn, As, Pb, Al Cd, Mn, phenols and pesticides as seriously polluted. Turbidity, Fe, Zn, As, Pb, Cd and pesticides pollutants may be from domestic waste and run-off from agricultural farmlands which surround almost all surface water sources. Aluminium and Mn are in toxic amount in Alisols and Crisols (Delvaux & Brahy, 2001) and can be attributed to their high index values due to run-off from soils. Phenols are from decomposed water hyacinth, grasses, and leaves mainly in Nagane, Karkashe and Magama dams as well as Nassarawa and Magama streams. Water sources with microbial coliform bacteria were strongly polluted and were observed to be from open defecation, access to water by livestock and run-off from human and animal feaces in the environment. Moderately polluted water sources contained Mg, Cu, NO_3 and Cl. Fluoride, Ca, Cr, pH, EC, TDS, $CaCo_3$, and SO_4 were not polluted. Seriously polluted water sources contained Pb, Cd, Mn, Al, Fe and turbidity largely present in surface water sources as reported in Ilorin and Egypt (Mohamed, Ali, Ibrahim, Ayman & Seliem, 2014; Ogunkunle, Mustapha, Oyedeji & Fatoba, 2016) but not in agreement with Hefni (2016) who found surface water of Indonesia not polluted in these parameters.

Table 3 Pollution load indices of surface and groundwater parameters

Para.	Mean Surface	Calculated PLI	Status/ Remark	Mean Ground	Calculated PLI	Status/ Remark
pH	7.285	0.90182	not polluted	7.24	0.87348	not polluted
Turb.	36.522	15.8432	seriously polluted	9.598	17.53628	seriously polluted
EC	217.25	0.47508	not polluted	742.05	2.03649	moderately polluted
TDS	133.6	0.47508	not polluted	391.6	2.03691	moderately polluted
$CaCo_3$	64.95	0.74336	not polluted	258.1	2.40873	moderately polluted
Ca	59.28	0.58571	not polluted	143.1	3.45681	strongly polluted
Mg	14.815	2.56424	moderately polluted	42.865	3.28977	strongly polluted
SO_4	12.855	0.2759	not polluted	25.91	0.58707	not polluted
NO_3	16.652	2.93341	moderately polluted	27.59	1.17593	slightly polluted
Fe	3.0175	23.6126	seriously polluted	2.264	23.57098	seriously polluted
Cl	24.155	2.40729	moderately polluted	14.62	1.14142	slightly polluted
F	0.292	0.61298	not polluted	1.798	2.74097	moderately polluted
Cu	1.228	2.06959	moderately polluted	0.4275	0.91935	not polluted
Zn	0.1653	7,975.31	seriously polluted	0.119	0.33899	not polluted
Mn	0.2305	7.77817	seriously polluted	0.0367	1.70711	slightly polluted
As	0.3257	148.492	seriously polluted	0.00855	0.12132	not polluted
Pb	0.3593	148.492	seriously polluted	0.1065	71.41778	seriously polluted
Al	0.28	7.17713	seriously polluted	0.0785	0.41421	not polluted
Cr	0.0212	0.96985	not polluted	0.0146	0.27279	not polluted
Cd	0.3218	447.834	seriously polluted	0.0009	1.17851	slightly polluted
Phe.	0.0047	28.2842	seriously polluted	0.00095	0.07107	not polluted
Pest.	0.0273	14.1421	seriously polluted	0.004	0.82843	not polluted
TC	12.75	3.41421	strongly polluted	7.1	1.27279	slightly polluted

Results also showed the groundwater sources were seriously polluted with turbidity, Fe, and Pb attributed to run-off and decomposition of Pb products into open dug-wells, strongly polluted with Ca and Ma, and moderately polluted with TDS, EC, hardness and fluoride attributed to geogenic factors such as rocks weathering and dissolution. Due to the effect of leaching and location closed to latrines and soak-away systems, groundwater sources were slightly polluted with total coliform bacteria, nitrate and chloride as well as Cd and Mn attributed to run-off in open wells. The groundwater sources was found not polluted with pH, SO_4, Cu, Zn, As, Al, Cr, phenols and pesticides. This result is similar to that of Amadi et al (2015) who found serious pollution of groundwater sources with turbidity, Fe, Pb and Mn in Minna due to run-off, and coliform bacteria for locating them closed to latrines and soak-aways. Elumalai, Brindha, and Laksmana (2017) also reportedstrong pollution groundwater sources with Ca nd Mg South Africa due to geogenic factors. On the contrary, Haji, Melesse and Reddi (2016) found groundwater of southern Florida not polluted with all these parameters.

Calculated Chronic Daily Intake and Health Risk Index of Surface Water Sources

The mean concentrations of Al, As, Cd, Mn and pesticides were above recommended limits. Computed HRIs for children also showed As, Cd, Pb and Al had index values of 33.32, 9.84, 2.75 and 2.14 respectively above unity as well as 30.02, 8.94 2.49 and 1.94 for adults in the same order (Table 5). Therefore, residents that consume these water sources are vulnerable to toxicities of these metals. Arsenic toxicity includes; skin manifestation, visceral cancers, and vascular disease. While that cadmium toxicity results in kidney damage, renal disorder, and human carcinogen. Lead damage the fetal brain, causes diseases of the kidneys, circulatory system, and nervous system, while aluminum results in neuro - degenerative disorder (Liu & Ma, 2020). None observance of protection zones around water points, indiscriminate waste disposal system and use of agro-chemicals on farmlands aided by run-off were responsible for the surface water contamination with heavy metals. Lohdip, Gongden and Pam (2012), and Gongden and Lohdip (2015) have also reported As, Cd, Pb and Al of up to 2.11, 2.35, 1.98 and 3.52 respectively in Ori and Kwaikong dams in

Langtang South LGA, and Ramadan (2017) also found As, Cd and Pb far above limits in streams and ponds of Wyitt village in Jos-Bukuru Metropolis. Similarly, Rasool, Farooqi, Xiao, Masood, Kamran and Bibi, (2016) reported HRIs of As, Cd, Cr, Al and Pb as 1.5, 4.2, 8.9, 4.2 and 3.7 respectively in surface water sources of Tehsil Pakistan largely to anthropogenic contamination. The overall HRI of surface water was 50.27 for children and 40.30 for adult far above limits posing serious health risk to both groups. Lar, Ozoji and Jibo (2014) had reported similar HRI of 30 and 25 for children and adults in soils Zamya area in Langtang South.

Table 5 Summary of chronic daily intake and hris of metals in surface water sources

Para	Mean Conc.	CDI Children	HRI Children	CDI Adult	HRI Adult	RfD
F	0.292	0.00892966	0.111620	0.00011265	0.001408	0.08
Cu	1.228	0.03755352	0.938838	0.03411111	0.852777	0.04
Zn	0.1653	0.00505505	0.168501	0.00459166	0.153055	0.03
Mn	0.2305	0.00704893	0.352446	0.00640277	0.320138	0.02
As	0.3257	0.00996024	33.320080	0.00905277	30.017590	0.0003
Pb	0.3593	0.01098776	2.746940	0.00998055	2.495138	0.004
Al	0.28	0.00856269	2.140672	0.00777777	1.944442	0.004
Cr	0.0212	0.00064832	0.216106	0.00058888	0.196296	0.003
Cd	0.3218	0.00984097	9.840970	0.0093888	8.938888	0.001
Phe	0.0047	0.00014373	0.071865	0.00013055	0.065277	0.002
Pest	0.0273	0.00083486	0.041743	0.00075833	0.037916	0.02
Fe	3.0175	0.09227828	0.307594	0.08381944	0.279398	0.3
		Total	50.27	Total	45.30	

Calculated Chronic Daily Intake and Health Risk Index of Groundwater Sources

Calculated CDIs of metals in Table 6 revealed none exceeded the recommended daily dose limits. Similarly, none of the metals HRI was greater than unity (>1), indicating none of the metals analyzed pose serious health risk in groundwater sources for both children and adults. However, cumulatively HRI for children and adults exceeded unity with values of 3.90 and 2.54 respectively which pose immediate heath risk to the people. These results were similar that of Inam, Etim and Offiong (2014) in groundwater sources of Akwa Ibom who found HRIs of all individual metals less than unity but with a cumulative index of 5.25 and 1.62 for children and adults respectively. Olagunju, Akawu and Ugokwe (2020) also reported cumulative HRI of metals of up to 8877.94 and 930.65 for children and adults respectively in selected locations in Ibadan. On the contrary, Khan et al (2013) and Nawab et al (2017) found cumulative HRI of metals less than unity in groundwater of Swat valley and Bunner district all in northern Pakistan.

Table 6 Summary of Chronic Daily Intake and HRIs of Metals in Groundwater Sources

Para.	Mean Conc.	CDI Children	HRI Children	CDI Adult	HRI Adult	RfD
F	1.7989	0.05501223	0.687618	0.04996944	0.624305	0.08
Cu	0.4275	0.01307339	0.326834	0.01187500	0.296875	0.04
Zn	0.1195	0.00365443	0.121814	0.00331944	0.110648	0.03
Mn	0.0367	0.00112232	0.056116	0.00101944	0.050972	0.02
As	0.0085	0.00025993	0.866462	0.00023611	0.787037	0.0003
Pb	0.1065	0.00325688	0.814220	0.00295833	0.739583	0.004
Al	0.0785	0.00240061	0.600153	0.00218055	0.545139	0.004
Cr	0.0146	0.00044648	0.148827	0.00040555	0.135185	0.003
Cd	0.0009	0.00002752	0.027523	0.00002500	0.025000	0.001
Phe	0.0010	0.00003058	0.015290	0.00002777	0.013888	0.002
Pest.	0.0040	0.00012232	0.006116	0.00011111	0.005555	0.02
Fe	2.2649	0.06926299	0.230876	0.06291388	0.209712	0.3
		Total	3.90	Total	2.54	

CONCLUSION

Drinking contaminated water poses high risk to public health but domestic water quality is not monitored in Langtang area. This study revealed domestic water sources of Langtang area were polluted with 67% of the parameters analysed and health risk indices of both surface and groundwater sources were greater than unity (HRIs >1). Therefore consumption of these water sources portends a major health risk to the local population and is responsible for the high incidence of diseases. Stagnation and anthropogenic activities such as uncontrolled waste disposal, excessive use of agro-chemicals on farms, open defecation, run-off and none observance of protection zones are major causes of water contamination. Therefore, it is strongly recommended that domestic water sources in the area should not be used for drinking purposes without treatment and the State or Local Governments should provide alternative drinking water because of the potential health risk posed by heavy metals.

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