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Physico-Chemical Analysis of Domestic Water Used by the Community of College of Agriculture and Its Environs, Maiduguri, Nigeria

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Abstract

This research study focuses on water sanitation and its environmental security and hazards; study was conducted on Physico-chemical analysis of domestic water used by the community of College of Agriculture and its environs, Maiduguri. The methods used were as described by Cheesbrough [1], Gwana, *et al.* [2] and Association of Analytical Chemists [3]. 200 mls of water sample each from the 8 water stations (A to H) were sampled; colour, tastes, pH, temperature, turbidity, mean concentration of some heavy metals, macro-elements and ions analysed each in triplicates were determined each in triplicate. The results obtained revealed that the colour and organoleptic (aesthetic) of the water samples were normal, with exception station E. The pH was within the ranges of 6.8 to 8.3, temperature (22 to 32 OC) and turbidity ranged from 1 to 4 TU. The mean concertation levels of the metals and ions in sample from the water stations; A ranged from 0.07 to 186 µg / l, B (0.01 to 108 µg / l), C (0.03 to 172 µg / l), D (0.01 to 122 µg / l), E (0.01 to 68 µg / l), F (0.03 to 102 µg / l), G (0.01 to 187 µg / l) and station H ranged from 0.02 to 98 µg / l. Metals and ions not detected in the water sampled from the stations were; Copper and Lead in station C, Copper in statin D, and Fluorite in station F, G and H respectively. Conclusively, only water from station E (313 TU / ml) exceed the standard recommended values for safe drinking water, but all the parameters determined in this study are within the recommended values by WHO. There is the need for sanitising measures, as recommended by WHO methods, in the community to have safe drinking water and their domestic activities within the said study area the world at large.
Keywords: Concentration levels; Domestic activities; Elements and ions; Heavy metals; Standard values; Water sanitation.

1. Introduction

Historically, the available of water supplies has determined where villages, towns, and cities are sited. Nomadic peoples and animals may travel hundreds of miles over the course of a year following the seasonal variation in rainfall [1, 4]. Water is a life supporting resource and the importance of water as a resource is not only tied to its quantity and availability, but also to its quality in terms of table water [5, 6]. Water is the basic of life on which all life depends on for survival. It is a very valuable but finite natural renewable resource, hence, the need for proper planning, management, and development of this valuable resource in order to prevent pollution as well as to harmonize its availability when the demand for different uses become necessary [7, 8]. World Health Organization [9], estimated that 2.6 billion people have no access to improved sanitation facilities. Life can't do without water, ranks as the most important [10].

A person can survive only eight to ten days without water, whereas it takes weeks or even months to die from a lack of food. Water circulates through our body and lymphatic system, transporting oxygen and nutrients to cells and removing wastes through urine and sweat [11]. Water also maintains the natural balance between dissolved salts and water inside and outside of cells. Our joints and soft tissues depend on the cushioning that water provides for them. While water has no caloric value and therefore is not an energy source, without it in our diets we could not digest or absorb the foods we eat or eliminate the body's digestive waste [12-14]. Water exists in many places and forms which are categorised as surface (ocean, polar, ice caps, rivers, lakes, rain water, etc.), atmospheric (water vapour)

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and ground water (in aquifers) which makes up about 41.3 % of the world water and 20 % of the fresh water supply, which is about 61 % of the entire world's domestic fresh water supply. Ground water is one of world's 'hidden' resources. Many consider ground water a potential source of drinking water that cannot be polluted because it is naturally protected from pollution by layers of soils and rocks, yet pollution of ground water has always been reported, because of the close link to human activities [4, 8]. Water system may be static (lentic) such as lakes, reservoirs, or flowing (lotic) such as rivers, rainwater, ditches, and streams [15, 16]. Fresh water quality is not constant; it varies with the time of the day, season, weather conditions, water source, soil type, temperature, stocking density, and feeding rate [2, 16]. Virtually, water quality management must be maintaining, a change in one of these factors may result in change to one or more of the other factors that have been reported to affect the quality of a water body [5, 10]. All these factors and many more, make water a substance of great importance. From a strictly chemical point of view, the remarkable thing about water is the amount of hydrogen bonding it has, both in the solid (ice), gaseous (steam) and in the liquid form. If it were not for the fact that hydrogen bonds are of intermediate strength (stronger than Van der Waals bonds but weaker than ordinary ionic or covalent bonds) then life as we know it could not exist and the world would be without rivers, lakes, or seas [2, 4, 17].

It is important to evaluate the beneficial uses of watershed in order to access the impact of pollution. Some watersheds have a greater number of beneficial uses and need greater protection from potential degradation. In overall water budget, human consumption of water for domestic activities and commercial enterprise accounts for a small percentage of annual rainfall. However, human actions have a wide ranging effect on a watershed's hydrologic balance, both water quality and quantity [18, 19]. Accordingto World Health Organization [9], many water sources in developing countries are unhealthy; this is because they contain harmful physical, chemical, etc. agents. To maintain good health, however, not only must a water supply be safe to drink, it must also be; available in sufficient quantity for all purposes, easily and safely accessible by all the community available all the time or when it is needed, available at affordable cost and it should also meet local standards for taste, odour, and appearance [1, 9]. A safe drinking water should conform to the following water quality characteristic; it should be free from pathogenic organisms, low in concentration of compounds that are toxic to man, livestock, and plants, and finally free from compounds that cause offensive taste and odour [1, 7].

Growth and nutrition in young children are also adversely affected by contaminated water supplies, poor hygiene and inadequate sewerage. The United Nations had declared 2005 to 2015, the *'Water for Life Decade'* with focus on water – related issues and a goal of having by 2015 reducing the number of people with no access to sustainable safe drinking water and basic acceptable sanitation. Among the issues identified as priority for decades (i.e. safe water, better – health – water for life decade) are water scarcities, sanitation access, disaster prevention, trans – boundary water issues, gender issues, capacity – building, financing, valuation, integrated water resources management, environment and biodiversity, food and agriculture, pollution and energy [1, 20].

Many water sources in the developing countries are unhealthy, and they contain harmful physical, chemical and biological agents. This may not be different from the communities of Maiduguri, and Nigeria at large. The aims and objectives of this research study are to determine the Physico – chemical (physical characteristics and some of the elements and heavy metals) in water used for domestic activities by the community of Mohamet Lawan College of Agriculture and its environs, Maiduguri, Nigeria.

2. Methodology

2.1. Study Area and Location

The study was conducted within the community of Mohamet Lawan College of Agriculture and its environs, Maiduguri. Maiduguri is the capital of Borno State of Nigeria, located in the North – Eastern region of Nigeria, and is among the six geo – political zones of the Federal Republic of Nigeria. Maiduguri shares local boundaries with Konduga, Jere and Mafa Local Government areas, with majority of the local people are small scale business men, farmers, fishermen and herdsmen, Islamic and Western Scholars do exist [21]. The major languages are Kanuri, Shuwa – Arab, Hausa and English respectively. Maiduguri has an area land-mark of about 300 square kilometres (300 km^2), which lies between latitude 12^o North to 13^o North and longitude 13^o East to 15^o East respectively. It has an estimated population of about 629, 486 people, out of which 340, 809 are males and 288, 977 are females. An area density of approximately, 0.0005 km^2 per person [22]. The climatic condition in this area is of a hot dry season (27 ^oC to 42 ^oC), and an annual rainfall of 500 to 600 mm has been recorded [21].

2.1.1. Water Sampling Station Areas

***i. Station A*:** - This is situated between the female and male students' hostels of the College. It is a concrete Reservoir 'Dam' constructed for the purposes of reserving and storing of water from tube well which was connected through polythene pipe.

ii. Station B: - This station is situated behind Forestry Technology Department. It is an overhead tank connected to a tube well 'Bore – Hole' for the purposes of storage of water. Sample of water was taken as recommended and with the accordance of the method described by Cheesbrough [1].

iii. Station C: - This station is at the Nursery unit of the Forestry Technology Department of the College. It is also a concrete reservoir which is connected to a Bore – Hole just nearby.

iv. Station D: - This water station is located at the College Livestock Ban, which is a tube well connected to surface tank and water fed large troughs or basins and a reservoir purposely constructed and made for feeding the livestock.

v. Station E: **-** This water station is a river Kumodu Gana, which passes through the college farm down to Jere basin where it empties it content to the fields. To this river, domestic wastes and influents from the abattoir and tannery flow down in to the river. Also, wastes from farmers and their washed away of their tools, and the rain falls wash off both fertilizers which run down in to the river as contaminants, Water samples were collected according to the method described by Cheesbrough [1].

vi. Station F: - This is a tube well connected to a concrete reservoir through a polythene pipe which is located at the Borno State Agriculture Mechanisation Agency (BOSAMA), which is adjacent to the College.

vii. Station G: - This water station is a tube well connected to a mechanical pump which is located at Farm Centre Quarters. Water sample was tapped according to the method described by Cheesbrough [1].

viii. Station H: - The water station H, is a reservoir connected to a Bore – hole at Alhaji Dawuds' compound and premises, which was located at Goni Kachallari village opposite Mohamet Lawan College of Agriculture, Maiduguri. Water was sampled according to the method described by Cheesbrough [1].

2.2. Materials used

Apparatus and reagents used under cleaned and hygienic environment, in the course of execution of this research study were of analytical grade. Standard operation procedures (SOP) were followed and all precautions were observed.

2.3. Methods Used

The methods used in this research study were the physical and chemical techniques, as in the methods described by Association of Analytical Chemists [3] and Cheesbrough [1]. The methods were divided into six (6) experimental stages. These stages were: - Water samples collection from eight stations within the study area, measurements of the pH, temperature, turbidity, determination of the colour and aesthetics of the water samples, determination of the heavy metals and macro – elements and ions by using AAS and flame photometric techniques of water analyses.

2.3.1. Water samples collection

Procedure: **-** The study area was randomly divided in to eight stations, namely; station A, B, C, D, E, F, G and H. At 6:00 AM hours (in the morning hours), 200 mls of pooled water samples were collected in to sterile plastic bottles from each station, properly screwed capped and labeled with the following information; date and time of collection, name of the station, and volume of water sample collected. The water samples were packed in a cold – chain container (Avoid deterioration and autolysis if any) and transported to the Laboratory for analysis. Sample of water was taken from the various water stations as recommended and with the accordance of the method described by Cheesbrough [1].

2.3.2. Measurements of pH and Temperature of the Water Sampled

Procedure: **-** The pH of the water samples was measured by using digital pH meter at the point of sample collection. This was done by deepening the electrodes point of the pH meter in to the water sample for thirty (30) seconds; it was then rinsed with distilled water and deionised water finally. Also measurement of temperature was performed by deepening the bulb end of the thermometer for one (1) minute and the readings were recorded, and then rinsed with distilled and deionised water after each reading was recorded.

2.3.3. Measurements of Turbidity of the Water Samples by Using a Calibrated 5 – 25 TU Turbidity tube (PT 513)

Procedure: **-** The two tubes were joined together by passing the upper tube into the lower one and the black cross at the bottom of the tube was seen and noted. The tube was held over a white surface (a white tile surface), viewed through the tube, then the water sample was dispensed slowly in to the tube until the black cross was no longer visible. The formation of air bubbles was avoided. The turbidity unit, that is, the graduation which corresponded to the meniscus (level) was taken and recorded.

2.3.4. Assessment of Colour and Organoleptic (Aesthetic), Odour and Taste

Procedure: - F**or** this experiemenr,100 mls of the collected water samples from each of the eight stations were subjected to an assessment, 24 volunteers (person) were chosen to assess and make observations on the colour, odour and taste of the water samples. The volunteers were grouped in to three (3), and each group had eight (8) members. Each member of a group was issued with an information form (in form of simple structured and closed – ended questionnaire) for the purpose of data collection on the colour, odour and taste of the water sampled. The filled – in forms were retrieved from the volunteers, and the results collected are in triplicate fold (i.e. three (3) times).

2.3.5. Determinations of some Heavy Metals and Elements

Procedures: - Determination of chromium element in the water samples. The atomic absorption spectrophotometer (AAS) was turned on by pressing the button 'ON' for 5 minutes and then scrolled to select the all programme list, and from the testing menu, chromium was selected. 10 mls of the water sample was dispensed in to clean, grease free tube with caps, closed and inserted in to the chamber and the lid closed. Scan blank was selected on the spectrophotometer and the tube was removed. 0.1 g of chromium powder was added in to the tube, the cap was closed and shaken to mix until dissolved and disassociated. The mixture was allowed to stand for 3 minutes for the development of colour. The mixture or suspension was filtered in to a clean, grease free tube. Mixed and inserted in to the chamber, the lid was closed and scan sample was selected. The reading was taken and recorded. Each water sample was treated the same and as such. The screening and evaluations of calcium, cadmium, copper, fluoride, potassium, lead, manganese, nitrate and zinc in the water sample A, B, C, D, E, F, G and H were prepared and the AAS was used to determine and evaluate the heavy metals and elements, as described by Association of Analytical Chemists [3].

3.4. Statistical Data Analysis Used

Data obtained from this research study was subjected to statistical analysis using mean for the measurement of central tendency, and standard deviation for measurement of dispersion and or discrepancy within the variables, as described by Stroud and Booth [23].

3. Results

The results (data) obtained from this research study were analysed and presented in the tables below as follows:

Table 1 showed the results obtained from the assessment of colour and organoleptic (aesthetic) appearance of the water sampled from the eight water stations examined. The colour of the water samples was normal, except water sample from station E, which was brownish in colour. Water samples in all of the stations were odourless (normal), except in water from station E, which when perceived, smelt a fishy odour. The taste of the water sampled in all of the stations was normal (tasteless), except water from station E which tasted salty.

Table 2 showed the results of the physical parametric values (pH, temperature, and turbidity) of the water sampled and examined from the eight stations mentioned. The mean pH of the water samples was within the range of 6.8 to 8.3; sample A had 6.9, B (7.0), C (7.2), D (7.8), E (8.0), F (8.3), G (6.8) and H (7.3). The mean temperature (^{O}C) of the water samples ranged from 22 to 32 ^{O}C; sample A had 27.9 ^{O}C, B (30.9 ^{O}C), C (29.0 ^{O}C), D (30.2 ^{O}C), E (25.9 ^{O}C), F (32.0 ^{O}C), G (25. 3 ^{O}C) and H (22.0 ^{O}C). Then, the mean turbidity (TU) of the water samples ranged from 1 to 4 TU; water sample A had 1 TU, B (1 TU), C (2 TU), D (3 TU), E (4 TU), F (3 TU), G (1 TU) and H had 2 turbidity units respectively.

Table 3 showed the results of the chemicals (some heavy metals macro-elements and ions) determined from the water sampled in each of the eight water stations given in microgram per litre (µg / l). In water sampled from station A (sample A), the mean concentration levels ranged from 0.07 to 186 µg / l; Calcium (Ca) had the mean concentration level of 186 µg / l, Cadmium (Cd) had 0.28 µg / l, Chromium (Cr) had 0.08 µg / l, Copper (Cu) had 0.13 µg / l, Fluoride ion (Fl^-) had 0.08 µg / l, Potassium (K) had 2.08 µg / l, Manganese (Mn) had 0.31 µg / l, Nitrite ion (N^-) had 0.07 µg / l, Lead (Pb) had 0.15 µg / l and Zinc (Zn) had 0.08 µg / l.

Station B, had the mean concentration levels ranging from 0.01 to 108 µg / l; Ca had the mean concentration level of 108 µg / l, Cd (0.07 µg / l), Cr (0.16 µg / l), Cu (0.01 µg / l), Fl^- (0.01 µg / l), K (1.53 µg / l), Mn (0.40 µg / l), N^- (0.18 µg / l), Pb (0.15 µg / l) and Zn had 0.21 µg / l.

Station C, had the mean concentration levels ranging from 0.03 to 172 µg / l; Ca had 172 µg / l, Cd (0.15 µg / l), Cr (0.16 µg / l), Fl^- (0.05 µg / l), K (0.83 µg / l), Mn (0.28 µg / l), N^- (0.28 µg / l), Zn (0.03 µg / l). Cu and Pb were not detected.

Sample D, had the mean concentration level ranging from 0.01 to 122 µg / l; Ca had a mean concentration of 122 µg / l, Cd (0.22 µg / l), Cr (0.01 µg / l), Fl^- (0.03 µg / l), K (1.47 µg / l), Mn (0.42 µg / l), N^- (0.03 µg / l), Pb (0.2 µg / l) and Zn had 0.21 µg / l. Copper was not detected.

Sample E, had the mean concentration levels ranging from 0.01 to 68 µg / l; thus, Ca had 68 µg / l, while Cd, Cr, Cu, Fl^-, K, Mn, N^-, Pb and Zn were with 0.036 µg / l, 0.1 µg / l, 0.38 µg / l, 0.01 µg / l, 2.9 µg / l, 0.36 µg / l, 0.98 µg / l, 0.1 µg / l and 0.04 µg / l.

Station F, had mean concentration of 0.03 to 102 µg / l; 102 µg / l, 0.34 µg / l, 0.03 µg / l, 0.1 µg / l, 1.04 µg / l, 0.19 µg / l, 0.52 µg / l, 0.09 µg / l, and 0.12 µg / l for Ca, Cd, Cr, Cu, K, Mn, N^- Pb, and Zn. Fluoride ion was not detected.

Sample G and H, were sampled; the mean concentration levels of these samples ranged from 0.01 to 187 µg / l for station G and 0.02 to 98 µg / l for station H. Station G had 187 µg / l, 0.25 µg / l, 0.08 µg / l, 0.01 µg / l, 1.44 µg / l, 0.24 µg / l, 0.13 µg / l, 0.05 µg / l, and 0.34 µg / l for Ca, Cd, Cr, Cu, K, Mn, N^- Pb, and Zn. While, station H had the following mean concentration levels of 98 µg / l, 0.17 µg / l, 0.05 µg / l, 0.05 µg / l, 2.07 µg / l, 0.21 µg / l, 0.02 µg / l, 0.06 µg / l, and 0.24 µg / l for Ca, Cd, Cr, Cu, K, Mn, N^- Pb, and Zn respectively. Fluoride ion was absent in both water sampled from station G and H, i.e. not detected.

Figure 1 showed the physical parametric mean and standard deviation values of water sampled from the source (water station A to H).

Figure 2 showed the mean and standard deviations for elements determined in water sampled in each of the eight stations (A to H).

Table-1. Physical Parametric Mean ± SD Values of Water Sampled

Water Sampled Stations (200 mls).	Physico – Parametric Values		
	pH	Temperature (^{O}C)	Turbidity (TU)
A	6.9 ± 2.4	27.9 ± 0.3	1 ± 0.1
B	7.0 ± 0.1	30.9 ± 0.2	1 ± 0.1
C	7.2 ± 0	29.0 ± 0.6	2 ± 0
D	7.8 ± 0.1	30.2 ± 0	3 ± 0.1
E	8.0 ± 0.1	25.9 ± 0.1	6 ± 0
F	8.3 ± 0.1	32.0 ± 0.1	3 ± 0.1
G	6.8 ± 0	25.3 ± 0.5	1 ± 0.1
H	7.3 ± 0.1	22.0 ± 0	2 ± 0.
Total (Mean ± SD)	59.3 (7.41 ± 0.56)	223.2 (27.9 ± 3.36)	17 (2.38 ± 1.13)

Keys: SD = Standard Deviation, mls = Millitres, pH = Hydrogen ions Concentration, ^{O}C = Degree Celsius, TU = Turbidity Unit

Table-2. Assessment of Colour and Organoleptic (aesthetic) Properties of Water Sampled

Types of Physical Parameter	Stations of Water Samples (200 mls)							
	A	B	C	D	E	F	G	H
Colour	colourless	colourless	colourless	colourless	brownish	colourless	colourless	colourless
Odour	odourless	odourless	odourless	odourless	fishy	odourless	odourless	odourless
Taste	agreeable	agreeable	agreeable	agreeable	salty	agreeable	agreeable	agreeable

Keys: mls = millitres

Table-3. Mean ± SD for Elements Determined in Water Sampled in each of the Eight Stations

Water Sampled Stations	Element Determined (µg / l)									
	Ca	Cd	Cr	Cu	Fluoride ion	K	Mn	Nitrite ion	Pb	Zn
A	186±1.73	0.28±0.01	0.08±0.01	0.13±0.01	0.08±0	2.08±0.13	0.31±0.01	0.07±0.03	0.15±0.01	0.08±0.01
B	108±0.58	0.07±0.01	0.11±0.01	0.01±0.01	0.01±0	1.53±0.01	0.40±0.02	0.18±0.01	0.12±0	0.21±0.01
C	172±0.58	0.15±0.01	0.16±0	nd	0.05±0.01	0.87±0.01	0.28±0.01	0.28±0	nd	0.03±0.01
D	122±0.58	0.22±0.01	0.01±0	nd	0.03±0.01	1.47±0.06	0.42±0.01	0.03±0.01	0.2±0.06	0.21±0.01
E	68±0.58	0.36±0.01	0.1±0.01	0.38±0.01	0.01±0	2.9±0.12	0.36±0.01	0.98±0.01	0.1±0.01	0.04±0
F	102±0.58	0.34±0.01	0.03±0.01	0.1±0.01	nd	1.04±0.01	0.19±0.01	0.52±0.01	0.09±0.01	0.12±0.01
G	187±0.58	0.25±0.01	0.08±0.01	0.01±0	nd	1.44±0.01	0.24±0.01	0.13±0	0.05±0.01	0.34±0
H	98±0	0.17±0.01	0.05±0	0.05±0.01	nd	2.07±0.01	0.21±0.01	0.02±0	0.06±0.01	0.24±0.01
*WHO / AOAC.	?	0.33 mg / l	0.05 mg / l	2 mg / l	1.5 mg / l	?	0.05 mg / l	4.6 mg / l	0.01 mg / l	5.0 mg / l

Keys: nd = Not detected, ? = Not known as per the period of this work, µg / l = Micrograms per miles, mg / l = Milligram per litre.
***Comments:** Standard recommended values of metals, ions and elements in water as reported by WHO / AOAC, Revision 2, Section 973, 42B (b); 2007

Figure-1. Physical parametric Mean standard deviation values of water sampled

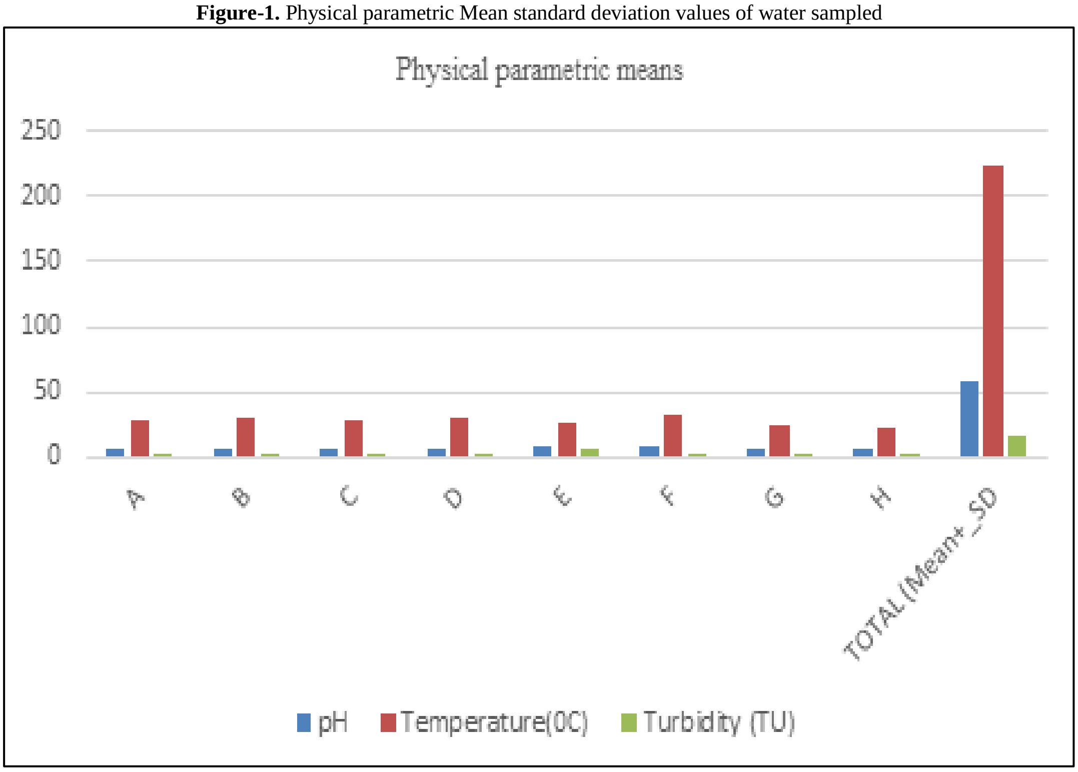
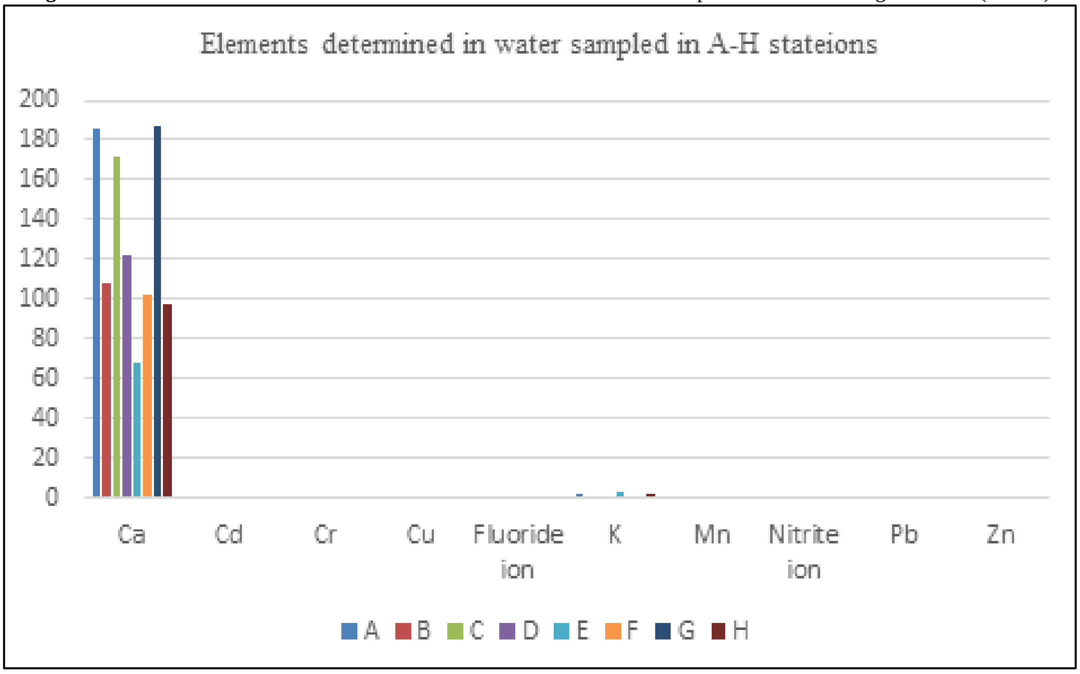


Figure-2. Mean and standard deviations for elements determined in water sampled in each of the eight stations (A to H)



4. Discussion

In the recent years, global warming and the changes in climate have caused some problems to food security, especially in terms of water for consumption and domestic purposes. Human activities are also not left behind, especially on rivers, streams, ditches, basins, dams, ponds and water reservoirs which contaminate the waters. Human and animal's activities, affects environmental waters bodies by dispersion of either one or both of the followings; defecation or domestic or industrial wastes materials there by contaminating their only water sources probably, and causes risk of health hazards. Water is a life supporting resource and the importance of water as a resource is not only tied to its quantity and availability, but to its quality in terms of potable drinking water and for domestic purposes.

Gardon [24], stated that 'most of the water used for domestic and industrial purposes is returned to the water cycle, and it is often contaminated with microbiological agents, some chemicals and heavy metals'. Water system may be either static lentic; e.g. lakes, reservoirs, or flowing lentic; e.g. rain water, rivers. Fresh water quality varies with the time of the day, weather conditions, water source, soil type, temperature and the frequent usage of the water by human and animal's activities, who are its contaminants. These, it is not constant. Virtually, water quality, quantity and its availability must be maintained for the purpose of consumption as clean table water and domestic usage, and any changes in these affect its quality body. According to World Health Organization [9] and Cheesbrough [1], they stated that, 'many water sources in developing countries are unhealthy, this is because, they contain harmful physical, chemical and biological agents'. To maintain good health, however, not only must a water supply be safe to drink, it must be available, easily and safely accessible by all the community, available all the time when it is needed, available at affordable cost and it should also meet local standards for taste, odour, and appearance, and in sufficient quantity for cooking, hand washing, personal bathing, cleaning and laundering clothes.

In the community of Mohamet Lawan College of Agriculture and its environs, Maiduguri, Borno State of Nigeria, numerous sources of water for consumption and domestic purposes do exist, and research was conducted on the standard quality of the waters for safe drinking water. The results obtained from this study revealed the physical parametric values (pH, temperature, turbidity, colour, odour, and taste (organoleptic; aesthetic), some chemicals (heavy metals, some ions, and some macro - elements) analysis and the parasites and bacteria of the water sampled from the eight water stations.

The pH mean value obtained was 7.41, which falls within the W.H.O. recommended standard Values (pH 6.5 to 8.3). The highest mean value recorded out of the eight stations was found to be in station F (pH 8.3), and the least mean value was found in station G (pH 6.8). This result obtained agrees with the work of Gwana, *et al.* [2]. All the values obtained from the measurement of the water sampled from these stations (station A to H) are fit for consumption as table water. The water in these stations is likely to have no impact on health in terms of physical condition (pH) of the water in the studied area, and met the WHO recommended standard parametric values for values table water.

For the temperature; the results of the measurements of the water sampled (sample A to G) in the studied area revealed that the parametric mean value was 27.9 ^{O}C. This was found to fall within the normal range room temperature within the tropics. The highest recorded mean value was found in station F (32 ^{O}C), and the least mean value was found to be in station H with a temperature value of 22 ^{O}C. These are fit for consumption for both human, animals and for domestic uses.

Among the physico – parametric values of the water sampled, measured within the studied area; turbidity (TU) was included. The results obtained revealed the mean value of 2.12 TU. That, only station E has the highest Turbidity Units mean value of 6 TU, and the least mean vale was found in station A, B, and G with 1 TU each respectively. And among all the water sampled from the eight stations, only station E (6 TU) is not fit for consumption and did not meet with the W.H.O. recommended standard parametric values for table water. To this, all the physico – parametric values obtained revealed that the water samples measured from these water stations in the studied area are fit for consumption and domestic uses, except for station E of which the mean value of the water turbidity was high, which exceeded the safe drinking water recommended value of the W.H.O.

In consideration to the other physico - parametric values, i.e. the assessed colour, and organoleptic (aesthetic) of the water sampled, that is, colour, odour and taste are that, all the water sampled from the water stations were found to be colourless, odourless and tasteless (that is normal), except water sampled from the water station E which was brownish in colour. The organoleptic or aesthetic, i.e. odour and taste of the water sampled from these eight water stations, only E did not meet with the required standard recommended status for safe drinking water (abnormal), because the water sampled from station E was found to smell fishy when perceived and tasted salty, thus, making it to be unfit for wholesome and domestic activities for both human and animals, for consumption as safe drinking water, i.e. table water and did not meet with the standard recommended status for safe drinking water laid down by W.H.O. Hence it is unsafe or unhealthy for consumption because of its colour, odour and taste, which conform to the reports of World Health Organization [9] and that of Cheesbrough [1], who in their report stated that "many water sources in developing countries are unhealthy, this is because, they contain harmful physical, chemical and biological agents". The safe drinking water or potable water has to be colourless, odourless, and tasteless or agreeable, but any changes from these render it as abnormal according to W.H.O.

Furthermore, the results of the determinations of the chemical analysis (heavy metals, ions and macro – element; Ca, Cd, Cr, Cu, fluoride ion, K, Mn, Nitrite ion, Pb and Zn) of the water sampled from the eight water stations in microgram per litre revealed that the mean concentration levels of heavy metals, ions, and elements (in µg / l) obtained falls within the range of the W.H.O. recommended standard parametric values for safe drinking water and for domestic activities.

When considering and comparing the W.H.O. standard recommended values of heavy metals, ions and elements concentration levels in safe drinking water (cadmium (0.33 mg / l), chromium (0.05 mg / l), copper (2.0 mg / l), fluoride ion (1.50 mg / l), manganese (0.05 mg / l), nitrite ion (4.6 mg / l), lead (0.01 mg / l). and zinc is 5.0 mg / l). With all the water samples collected from the water stations in this study, it can be said that they are healthy and safe, thus, they are found to be wholesome for consumption and domestic activities.

Among the heavy metals, ions and macro – elements determined from the eight stations in this study all were found not to exceed the W.H.O recommended standard values (in mg / l). The results revealed that station A contained calcium which had the highest mean concentration level of 186.0 µg / l and the least was nitrite ion with the mean concentration level of 0.07 µg / l. And when arranged sequentially, in descending order of magnitude of mean concentration levels of the chemicals obtained were Ca > K > Mn > Cd > Pb > Cu > Fl^- > Cr > Zn > NO^- respectively.

Consequently, water station B revealed that the mean concentration level of heavy metals, ions and macro – elements fell within the recommended parametric values for safe drinking water and domestic purposes. Calcium had the highest mean concentration level of 108 µg / l, while the least were copper and fluorite ion which had 0.01 µg / l each. Sequentially, their magnitude in descending order were as follow; Ca > K > Mn > Zn > NO^- > Pb > Cr > Cd > Fl^- > Cu.

Among all the water samples evaluated, from the eight water stations, only station C had two heavy metals (Cu and Pb) which were not detected. Calcium had the highest concentration level of 172 µg / l, while Zn had 0.03 µg / l, which was the lowest. The magnitude of the heavy metals, ions and the macro – elements that were detected in station C was as follow; Ca > K > NO^- > Mn > Cr > Cd > Fl^- > Zn respectively. All the values from station C did not exceed the W.H.O. recommended standard values of concentration levels in safe drinking water or table water.

In another development, the results obtained revealed that water sampled from station D had no copper, but calcium was detected with the highest concentration level of 122 µg / l and the lowest was chromium with 0.01 µg / l. These results fell within the WHO and AOAC of 2007 recommended parametric values for safe drinking water and domestic use. The sequence in terms of mean concentration levels magnitude was; Ca > K >Mn > Cd > Zn > Pb > Fl^- and NO^- > Cr. Thus, the sequence of mean concentration magnitude in numerical values was 122 µg / l > 1.47 µg / l > 0.42 µg / l > 0.22 µg / l > 0.21 µg / l > 0.2 µg / l > 0.03 µg / l and 0.03 µg / l > 0.01 µg / l respectively.

Another source of water used in this study was that of water station E, which is river called Kumodu Gana, i.e. meaning 'Small River' in Kanuri language. Water was sampled from the river, which is a flowing lentic source of water. Heavy metals, some ions and macro – elements were determined and the results obtained revealed the highest in mean concentration level was calcium with the value of 68.0 µg / l, while the least was Fl^- ion with a mean concentration level of 0.01 µg / l. All the mean concentration levels of the chemical elements determined in this research work were below the levels that World Health Organization (WHO) and Association of Analytical Chemists (AOAC) [25] recommend as standard values for safe drinking water and domestic use. This is also similar to the work of Gwana, *et al.* [6] who reported similar findings. The mean concentration levels of their magnitude, in sequence were; Ca > K > NO^- > Cu > Cd and Mn > Cr and Pb > Zn > Fl^-. Thus, water from this study was safe for drinking and domestic use by human beings and animals without any cause for alarm of health risks.

Furthermore, water sampled from water station F revealed that there was no Fluorite ion (Fl^-). Among the elements determined, calcium had the highest mean concentration level value of 102 µg / l, followed by potassium with 1.04 µg / l, nitrite ion (0.52 µg / l), cadmium (0.34 µg / l), manganese (0.19 µg / l), zinc (0.12 µg / l), copper (0.1 µg / l), lead (0.09 µg / l) and the least was chromium with 0.03 µg / l mean concentration value. These values were below the standard recommended parametric values reported by World Health Organization [26] and fit or wholesome for table water. A similar work had been carried out by Gwana, *et al.* [2], who reported that "the chemical analysis of water sampled from seven stations collected within the community of Mohamet Lawan College of Agriculture and environs, Maiduguri, met with the World Health Organization [9], World Health Organization [26] recommended standard parametric values for table water in terms of these elements determined". Sequentially, the mean concentration level of their magnitude in descending order was; Ca > K > NO^- > Cd > Mn > Zn > Cu > Pb > Cr respectively.

From the study, also water was sampled from station G, which revealed that there was no fluorite ion in it. The highest element determined was calcium which had the mean concentration level of 187 µg / l, seconded by potassium with the mean concentration level of 1.44 µg / l, then followed by zinc (0.34 µg / l), then 0.25 µg / l, 0.24 µg / l, 0.13 µg / l, 0.08 µg / l, and 0.01 µg / l for Cd, Mn, NO^- ion, Cr, and Cu respectively. In sequence, the magnitude of their mean concentration levels in descending order was; Ca > K > Zn > Cd > Mn > NO^- ion > Cr > Cu respectively. These mean concentration levels obtained revealed that it was below the standard parametric values recommended for safe drinking water and domestic uses by World Health Organization (WHO) and Association of Analytical Chemists (AOAC) [25]. The water was found fit and there is no risks of health hazards.

Lastly, the results obtained revealed that the water sampled from station H was also fit for drinking water as recommended by World Health Organization [9]. This was because; the mean concentration level values did not exceed the recommended parametric values for safe drinking water and there are no any risks of health hazards in terms of the chemicals determined in it. It revealed that, calcium had the highest mean concentration level value of 98 µg / l, and the lowest was nitrite ion (NO^- ion) had a mean concentration level of 0.02 µg / l. Fluorite ion was not detected from water station H, and the sequence in terms of mean concentration levels of magnitude in descending order was; Ca > K > Zn > Mn > Cd > Pb > Cr and Cu > NO^- (nitrite ion). Thus, the sequence of mean concentration level magnitude in numerical values in descending order was; 98 µg / l > 2.07 µg / l > 0.24 µg / l > 0.21 µg / l > 0.17 µg / l > 0.05 µg / l and > 0.05 > 0.02 µg / l respectively.

With consideration to the mean concentration levels of each chemical determined in each of the water station sampled, the results revealed that the ions, macro – elements, and heavy metals; fluorite and nitrite, calcium and potassium, cadmium, chromium, copper, manganese, lead and zinc which their mean concentration levels did not exceed the standard recommended parameters for safe drinking water as reported by World Health Organization (WHO) and Association of Analytical Chemists (AOAC) [25].

5. Conclusion

This study revealed the physical parametric values (pH, temperature, turbidity, taste, colour and odour), presence of some chemicals, ions and elements from the eight water stations within the community of Mohamet Lawan College of Agriculture and its environs, Maiduguri. The physical parameters of the water sampled met the W.H.O. recommended standard parametric values for table water in terms of pH, temperature, turbidity, taste, colour and odour, except water from station E. The determinations of some of the chemical analysis (some heavy metals, ions and macro – elements; Cd, Cr, Cu, Mn, Pb, Zn, Fluorite ion, Nitrite ion, Ca and K) from the eight water stations in microgram per mile (µg / l), it revealed that, their mean concentration levels were within the range values of the World Health Organization (WHO) and Association of Analytical Chemists (AOAC) [25] recommended standard parametric values for safe drinking water and for domestic activities. Therefore, apart from the water sampled from the water station E, (which was water sourced from the river Kumodu Gana), all the water sampled from these stations were fit for consumption and domestic activities, i.e. were found wholesome and domestic purposes, as recommended by World Health Organization (WHO) and Association of Analytical Chemists (AOAC) [25]; World Health Organization [9], World Health Organization [26]; Cheesbrough [1].

Recommendations

Based on the finding of this studied, the following recommendations were made;

The community of the study area should be enlightened on the World Health Organizations' recommended standard parametric values for drinking water and its purification. The community of the studied area should be enlightened on the sanitation measures in order to keep their household, environment and surrounding free from waste materials which should be burnt and buried in a pit. The Government, Non-Governmental Organization (NGO) or any authority concerned should assist and build more Bore Holes with polythene (PVC) pipes networks for safe water (drinking and domestic purposes) distributions within the community studied. Furthermore, students / researchers should be urge to intensive such research studies in the community and its environs are highly recommended.

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