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Physicochemical Analysis of Potable Water in Baham Community

Location: West Region of Cameroon

By

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ABSTRACT

Water samples were collected from four representative sampling points in different areas of Baham; 2 boreholes, a well, and a stream. Physicochemical analysis using gravimetric and titrimetric methods were carried out on the collected samples and they were analysed based on their temperature, pH, color, odour, total dissolved solids (TDS) and total suspended solids (TSS) content, sulphate, lead, and chloride concentration as well as water acidity and alkalinity. The results showed low pH values of between 5.39 and 6.11 for all samples, an average temperature of 20°C, agreeable colour, and odour for all samples but for the stream, which had colour, odour, very low TDS content of between 10-20 mg/l, TSS of between 10 and 50 mg/l, acceptable for all but the stream and well samples which had a concentration of 30mg/l and 50mg/l respectively, an extremely low chloride concentration level of 8-23 mg/l compared to WHO's recommended 250 mg/l, higher than acceptable sulphate contents of 246.9-493.8 mg/l and extremely high lead concentrations of 0.27-0.30 mg/l which is about 5 times the recommended 0.05 mg/l WHO permissible limit. The results showed higher than normal acidity values of between 60-110 mg/l and Alkalinity values of 50-150 mg/l which fall within acceptable limits. From the results above, it was concluded that the quality of water in Baham is not fit for consumption according to WHO standards. It is acidic, lacks essential minerals, is not properly disinfected, and has disturbingly high lead concentrations.

Keywords: Potable water, acidity, alkalinity, bacteriological, WHO standards, Microbial, contamination,

1. INTRODUCTION

Baham is a small community located in the West region of Cameroon. It is situated 250 Km from Douala and 20 Km from Bafoussam. It is the seat of the Upper plateau division and it constitutes the traditional Bamileke chiefdom. It is a hilly area with an elevation of 5,394ft (1,664m) and approximate population size of about 60,000 persons. It is made up of sixteen villages and it is bordered by Banjoun, Bayangam, Bahouan, Bamendjou, Bapa, Batie, Badenkop, and Bangou.

Water is an indispensable resource (Sushil et al., 2015). It is a naturally circulating resource occupying about 70% of human body mass and 71% of the earth's surface. Of this percentage, 97% of it is saline, 3% is fresh water and 1% of the 3% is trapped as groundwater in aquifers (Karthik et al., 2019). Water can be obtained from several sources including oceans, seas, streams, lakes, rivers, ponds, rain, springs, and wells. Of all these water sources, we have potable and non-potable water. Our radar is on potable water which is water that is free from disease-causing micro-organisms and chemical substances that are deleterious to health (Sadiya et al., 2018)

Water quality is an index of the good health and wellbeing of every society (Arun and Nabin, 2018). Ensuring good quality of drinking water is a basic factor in guaranteeing public health as drinking water plays a remarkable role in human infection and diseases (Emad et al., 2019). Environmental protection, sustainable development, and poverty reduction can be achieved by the availability and accessibility of clean, potable water (Al-Bratty et al., 2017). Poor water quality is considered one of the manifestations of poverty in developing countries (Aminu et al., 2017).

With a fast-rising population, rapid increase in urbanization, industrialization and anthropogenic activities, the rates of surface and groundwater pollution are soaring more than ever worldwide (Daud et al., 2017; Amanjot et al., 2015; Ugbaja and Otokunefor, 2015). It was observed that the cost of environmental degradation due to water pollution is relatively high with not only serious health and quality of life consequences but also poses a severe threat to the balance of aquatic ecosystems, economic development, and social prosperity (Aminu et al., 2017).

Pollution of consumable water could be from different sources such as insanitary conditions during borehole construction, splashing of runoffs into wells if left uncovered, flooding at borehole sites, leachate from old burned waste pits, or latrines, and even seepage through cracks into aquifers (Sadiya et al., 2018). A high level of fertilizer use will cause nutrients such as nitrogen and phosphorous to be washed from farms by erosion unto water bodies causing eutrophication leading to the growth of other microorganisms and causing contamination. Other contamination sources of freshwater are household wastes, sewage water, industrial effluent, synthetic detergents, and oil spills (Sadiya et al., 2018).

About 1.1 billion people lack access to safe drinking water sources with a majority of these people in Asian and sub-Saharan African countries (Ugbaja and Otokunefor, 2015). It has also been estimated that about 2.4 billion people lack adequate sanitation worldwide. Water-borne pathogens infect around 250 million people each year resulting in 10 to 20 million deaths worldwide. An estimated 80% of all diseases in developing countries are related to water and sanitation and 15% of all child deaths especially for children under the age of 5 years in developing countries, are a result of diarrhoeal diseases (Ugbaja and Otokunefor, 2015). The most susceptible people who die yearly to these infections are children, the elderly, and people with compromised immune systems (Sadiya et al., 2018).

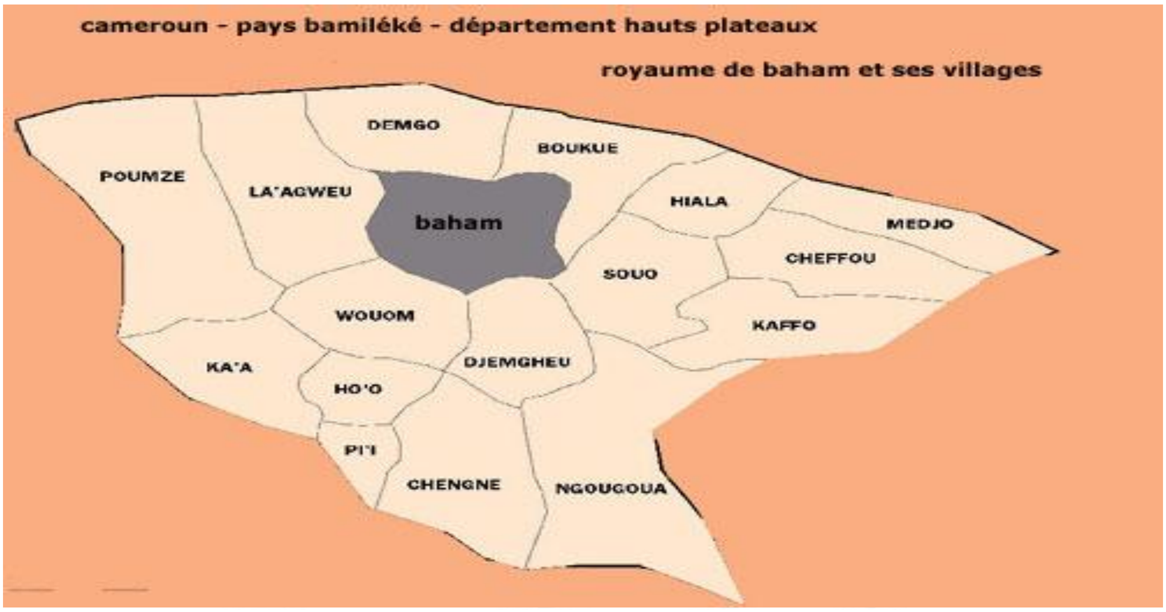


Figure 1: *Map of Baham and its 16 villages (Baham Council, 2021)*

Omam and Ayonghe (2015) conducted physiochemical and microbial analysis on 14 sachet water brands sold in Cameroon to determine their portability based on WHO standards. Their results indicated that only the pH, Total Suspended Solids (TSS), Electrical conductivity (EC), and Total Dissolved Solids (TDS) fell within WHO standards. Microbial analysis indicated that about 85% of the brands were unsuitable for consumption with some containing Escherichia coli (E-Coli) which indicate faecal contamination. The potential health consequences of microbial contamination are such that its control must always be of paramount importance and must never be compromised. WHO's guidance for drinking water quality is particular about the use of multiple barriers, from catchment to consumer, to prevent the contamination of drinking-water or to reduce contamination to levels not injurious to health. In fact, the preferred strategy is a management approach that places the primary emphasis on preventing or reducing the entry of pathogens into water sources and reducing reliance on treatment processes for removal of pathogens. Therefore, Omam and Ayonghe (2015) results called for further assessment of the policy and management of the sachet water industry of Cameroon.

Magha et al., (2015) conducted physiochemical and bacteriological characterization of spring and well water in Bamenda III which is in the North-West region of Cameroon. Samples were collected from four springs and three wells and analysed using the standard methods. Results showed that the waters were acidic (pH < 6.5), contained a whole lot of major cations and anions, and were highly polluted with bacteria. They concluded that the water was not suitable for drinking and domestic purposes.

Fonge et al. (2015) conducted a physiochemical analysis on streams flowing through an agro-plantation complex in Tiko, Cameroon. Two sets of water samples were collected from three streams flowing through the Tiko plantations and they were tested for nitrates, bicarbonate, zinc, iron contents, and turbidity. All values obtained from their analysis exceeded WHO and EPA quality standards.

Tamungang et al., (2016) conducted a physiochemical and bacteriological assessment on the Bambui community drinking water found in the North-West region of Cameroon. Samples of water were collected from the Niba, Atunui, and Tubah quarters of the Bambui town and analysed for their physical, chemical, and bacteriological characteristics using standard methods. The results obtained indicated that all the water samples were contaminated to different extents by bacteria and heavy metals due to little or no disinfection, uncontrolled defecation, pipe leakages, and the use of fungicides for agricultural activities. In a general view, more significant microbial risks are associated with ingestion of water that is contaminated with human or animal (including bird) faeces. Faeces can be a source of pathogenic bacteria, viruses, protozoa and helminths. Tamungang and his team advised that even though the water had no odour and it looks clean, it contains infectious bacteria and thus should be treated by chlorination or boiling before consumption.

Felaniaina et al., (2017) assessed the water quality of the surface water of the Bétaré-oya gold mining area in the East of Cameroon by collecting 71 water samples from 16 points. Analysis of physicochemical properties such as pH, EC, alkalinity, turbidity, TSS, cyanide (CN^-), heavy metals (Pb, Zn, Cd, Fe, Cu, As, Mn, and Cr) showed that the surface water from Bétaré-Oya was acidic to basic (5.40<pH<8.84), weakly mineralized (11.60<EC<122.10µS/cm) with a high concentration of TSS (2<TSS<8996.00mg/l).

Gapou et al. (2017) characterized the physicochemical and biological properties of sachet water sold in the political capital city of Cameroon, Yaoundé. Their study was carried out on 100 water samples representing 20 sachet water brands sold in the city. Their results showed that the pH and nitrates were in accord with WHO standards. However, the chloride ions were lower than the prescribed standards and 75% of the samples contained intestinal enterococci. The study conducted enabled them to conclude that the packaging material used and storage conditions (exposure to sunlight) can aggravate contamination.

In related research, Ndjama et al., (2017) analysed the physio-chemical and biological characteristics of the Nkolbisson artificial lake. Results of the analyses showed the lake was highly polluted retaining about 2535.49 tons/year of suspended solids in the rainy season and 1438.5 tons in the dry season.

Quality assessment on some springs in the Awing community found in the North West of Cameroon was carried out by Alakeh et al., (2017). They collected samples from the Achialum, Meupi, and Ala'amati quarters and analysed them for physiochemical and biological parameters using standard methods. Results of the analysis showed that these parameters fell below WHO standards and that the Achailum and Ala'amati springs were of relatively better quality than that of the Meupi which was found to be of very poor quality. The community of Awing was advised based on the results of this research to always boil their water before consuming it.

A similar analysis and water quality control of water sources in Bangolan in the North West region of Cameroon were carried out by Biosengazeh et al. (2017). 10 water sources were sampled and tested using standard methods. The results showed that the sources were moderately acidic to weakly basic, had low electrical conductivities and total dissolved solids, suggesting low mineralized waters which could lead to a shortage of essential mineral elements in humans. Turbidity was highly attributable to rains and faecal coli forms were found in all sampled sources. Statistical analysis revealed the significance of heavy rains on water parameters and health data revealed 1389 cases of water-borne diseases namely; typhoid, diarrhea, and dysentery necessitating control.

Fomenky et al., (2017) reported physiochemical analysis conducted on the soil and water sources on the Western flank of Mount Cameroon. From the results of the analysis, they concluded that the water was contaminated from natural sources such as weathering, erosion, and seawater intrusions, and anthropogenic sources such as waste from humans, laundry, fertilizers, and factories. They recommended stringent soil and water management schemes or legislations.

In the same vein, Belegfe et al., 2019 determined the impact of the physiochemical properties of water on the biodiversity and groundwater quality in Tiko, Cameroon. Their analysis showed that Tiko water had a high temperature (27±0.84°C), slightly acidic pH (6.42±0.45), high turbidity, weak mineralization, and high colour content. 6290 micro-organisms were identified during the sampling period belonging to 2 phyla, 9 classes, 29 families, and 26 identified genus/sub-families. The results obtained showed that the water is not good for consumption and requires serious treatment.

Nzeket et al. (2019) conducted an assessment on the physiochemical and heavy metal properties of groundwater in Edea, Cameroon. They collected samples from 8 randomly selected boreholes in triplicates bimonthly and analyzed them using standard methods. Analysis showed high temperatures (30.26±2.4°C), acidic pH, and weak mineralization. They also indicated that all the boreholes were contaminated by lead and 32.5% of them contained Manganese leading to the conclusion that the water of Edea is not suitable for human consumption and must be appropriately treated before any usage.

In another work, Njoyim et al., (2019) conducted a spring quality assessment and determined its effects on the health of the inhabitants of the Santa subdivision of the North-West region of Cameroon. Water samples were collected from Mbei, Mbu, Njong, and the Santa, Akum localities and analysed based on their physicochemical and bacteriological properties. All organoleptic and physicochemical properties except for iron fell between WHO permissible limits indicating no contamination. However, pathogens were present in the samples from the springs thus explaining the prevalence of water-borne diseases in Santa.

Tsama et al. in 2019 conducted physiochemical analysis and zero-valent iron treatment of borehole water in Maroua, Cameroon. Their analysis showed that while iron and chloride amounts were within WHO standards, all other measured parameters were beyond standards. The analysed water was treated with a Fe/sand mixture which improves its quality by removing colour and also improves its hardness. From the analysis, it was concluded that the water consumed in the Maroua I council area was not potable but could be rendered as such by the use of a cheap and simple filtration system based on Sand and Iron (Fe).

Ngakomo et al. (2019) determined the physicochemical and biological water quality of the water consumed in the Ngoumou rural council in Cameroon. Analysis revealed low organic pollution. Results showed that the waters were acidic, lowly mineralized, presented low oxygen saturation and lots of biological contaminants. Notably, the great majority of evident water-related health problems develop from microbial (bacteriological, viral, protozoan, or other biological) contamination, though a considerate amount of serious health issues may occur as a result of chemical contamination of drinking water. Thus, Ngakomo and his team made a serious conclusion that the communal waters were seriously contaminated and unfit for drinking.

In the year 2020, Biosengazah et al. assessed the groundwater quality of Baba I village in the North-West region of Cameroon to determine its suitability for domestic uses following WHO guidelines. Six water samples were collected and examined for organoleptic, physio-chemical, and bacteriological parameters using standard methods. Results showed that most of the sources were within WHO acceptable limits with pH varying moderately acidic to weakly basic. Chemical properties revealed all analysed ions were found within the WHO guidelines and sources ranged from soft to moderately hard with iron slightly exceeding the WHO 0.3mg/L guideline in the well of Kwebessi. Bacteriological analysis showed that waters were contaminated hence it was suggested that home treatment methods be implemented before consumption.

Mouhamed et al. (2020) conducted physiochemical characterisation and treatment on the waters of the Djouzami gold mining site in the Adamawa region of Cameroon. Samples of run-offs, stagnant water, and sediments were collected and analysed based on their pH, electrical conductivity, turbidity, and suspended solids and chemical constituents. The results showed that the mining site was slightly acidic to neutral ($5.93<pH<7.02$), turbid ($46\ mgL^{-1}<SS<200mgL^{-1}$), and polluted by inorganic substances (heavy metals such as Cd, Pb, and Fe) which exceeds the WHO standards. It should as well be noted that particular areas with aggressive or acidic waters, the use of lead pipes and fittings or solder can result in elevated lead levels in drinking-water, which cause adverse neurological effects WHO (2008).

In yet another research, Tamungang et al. (2020) conducted an evaluation of the surface and groundwater quality of the Bagante municipality in the West region of Cameroon. Samples were collected from 3 villages; Nenga I, Banekouane I, and "quartier 2"and analysed for physicochemical and bacteriological characteristics. The results obtained showed that the water samples were contaminated to different extents by phosphates, heavy metals, and bacteria. It was concluded that the water was unfit for consumption and could lead to serious health risks.

2. RESULT/EXPERIMENTAL (MATERIALS AND METHODS)

SAMPLE COLLECTION:

Water samples were collected from four locations which are representative of the water consumed in the entire Baham community. They were collected in 1.5ml bottles which were cleaned initially, labelled, and after sample collection, were immediately brought to the lab for physiochemical analysis.

The sample points used for analysis are presented in Table 1 below.

Table 1: Water sampling points.

Sample	Name of sample point	Source
S1	River Mafechup	Stream
S2	L'hotelFovu	Borehole
S3	Centre	Well
S4	Baham Stadium (Stade)	Borehole

MATERIALS:

The following materials were used for the analysis:

- pH meter
- Beaker
- Stirring rod
- Buffer solutions
- Thermometer
- Filter paper
- Measuring cylinder
- Conical flask
- Electronic balance
- Bunsen burner
- Burette
- Dropper
- Potassium chromate indicator
- Silver Nitrate solution
- Distilled water
- Concentrated Sulphuric Acid
- Concentrated Hydrochloric Acid
- Phenolphthalein and Methyl Orange Indicators
- 0.02N Sodium Hydroxide
- Erlenmeyer's flasks

ANALYTICAL METHODS

Physiochemical analysis of water was carried out based on the parameters and using the procedures outlined
below;

1) pH:

It was determined by a pH meter potentiometrically as follows;

- The pH meter was first calibrated with a buffer solution of pH 4.01 and pH 7 according to the manufacturer's calibration procedure.
- Water was transferred into a 50 ml glass beaker and stirred gently using a clean stirring glass rod.
- The water sample was then allowed to stand for 30 minutes to allow the temperature to stabilise and it was stirred occasionally in the course of waiting.
- The electrode of the pH meter was then immersed in the water sample while turning the beaker gently to ensure maximum contact between the water and the electrode.
- The pH meter was immersed for about 30 seconds in the sample before the pH was read to allow the meter to stabilize.
- The pH value was finally read when the meter stabilized and recorded to the nearest tenth of a whole number.

2) TEMPERATURE:

After adjusting samples to room temperature then the mercury thermometer was inserted into 5 ml of each sample and their temperatures were read off after about 3 minutes.

3) COLOUR:

Visual observation for any noticeable colour.

4) ODOUR

After sample collection, a clean bottle was half-filled with the water sample. A stopper was inserted on it and it was shaken vigorously for 2 to 3 seconds then quickly observed by placing nostrils close to the bottleneck and perceiving the released smell (sample was at room temperature).

5) GRAVIMMETRIC DETERMINATION OF TOTAL DISSOLVED SOLIDS IN WATER (TDS), [IS: 3025 (Part 16)]

Determination of Total Dissolved Solids in water was done as follows;

- 50 mlof the water sample was transferred into a measuring cylinder.
- It was filtered through a 250mm Whatman filter paper into a conical flask which had been weighed on a scale balance.
- The sample was heated in a water bath until all of it evaporated.
- The weight of the conical flask was measured after cooling and TDS was calculated using the following formula;
-

Calculation

$$\text{TDS (mg/l)} = \frac{\text{(Weight of dry solid+ conical flask)} - \text{(Weight of flask)}}{\text{Volume of Sample taken in ml}}$$

6) GRAVIMMETRIC DETERMINATION OF TOTAL SUSPENDED SOLIDS IN WATER [IS 3025: (Part 17)]

The TSS of samples was determined as follows:

- A filter paper was weighed on an electronic balance and its weight was noted
- 5 ml of water sample was filtered through the pre-weighed filter paper
- Filter paper was dried with direct sunlight to enable evaporation of all moisture
- It was weighed after drying to determine the TSS in 5ml water sample
- TSS was calculated from the above procedure using the following formula;

CALCULATION

$$\text{TSS} = \frac{\text{((Weight of filter paper + residue)} - \text{(Weight of filter paper))}}{\text{Volume of sample used}}$$

7) TITRIMETRIC DETERMINATION OF CHLORIDE CONTENT IN WATER BY kTHE ARGENTOMETRIC METHOD [IS: 3025 (Part 32)]

The chloride concentration of water samples was determined as follows;

- Silver nitrate (0.0141M) was prepared by dissolving 2.4 g of powdered $AgNO_3$ with distilled water and then it was made up to the mark in a 1000ml volumetric flask.
- The silver nitrate solution was transferred into a well rinsed 50 ml burette.
- Then, 50 ml of each water sample was measured using a measuring cylinder and

- 1.0 ml of potassium chromate indicator was measured with a dropper and added to the sample in the conical flask.
- The mixture was titrated with the silver nitrate solution in the burette to a pinkish-yellow endpoint.
- Titration was done thrice and the average volume of $AgNO_3$ used was recorded
- A blank value was established by titration with distilled water.
- Calculation of the concentration of chloride ions was done using the following formula

$$\textbf{Chloride (mg/l)} = \frac{\textbf{(V1-V2) X N X 34.45 X 1000ml sample}}{\textbf{V3}}$$

Where;

V1= Volume in ml of silver nitrate used in the solution
V2= Volume in ml of silver nitrate used in the blank titration
V3= Volume in ml of sample taken for titration
N= Normality of silver nitrate solution.

8) GRAVIMMETRIC DETERMINATION OF LEAD (Pb) IN WATER SAMPLES [IS: 3025 (Part 49)]

Gravimetric determination of lead in water samples was done as follows;

- 50 ml of the water sample was measured using a measuring cylinder
- 5 ml of sulphuric acid was added to it
- The mixture was heated in a water bath for 30 minutes
- The beaker was left to cool for about 15 minutes
- 100ml of distilled water was measured with a cylinder and added to the mixture and then allowed to cool in an ice bath for it to precipitate lead sulphate ($PbSO_4$)
- The precipitate was filtered using a filter paper and washed with 2% sulphuric acid followed by distilled water
- The precipitate was dried under the sun for about 5 hours
- The precipitate was weighed using a scale balance and the concentration of lead was recorded in mg/l.

9) Gravimetric Determination of Sulphate Content in Water [IS: 3025 (Part 24)]

Sulphate ions are precipitated by the addition of barium chloride solution to the water sample, acidifying it and boiling it to near boiling point.

$$SO_4^{2-} + BaCl_2 \xrightarrow{\text{HCl medium}} BaSO_4 + 2Cl^-$$

Sulphate content in water samples was determined as follows;

- 100 ml of water sample was measured using a measuring cylinder
- 2 ml of concentrated HCl was added to it and it was heated to near boiling point
- 10% $BaCl_2$ solution was prepared by dissolving 2 g of $BaCl_2$ crystals in 20 ml distilled water
- 5 ml of the $BaCl_2$ prepared was added to the sample already treated with Hydrochloric acid and it was heated to near boiling point
- It was allowed to chill to precipitate $BaSO_4$ and the sulphate was removed from the solution as $BaSO_4$ precipitates.

- The precipitate was filtered and washed with water to remove chlorides, it was dried and weighed.
- From the weight of the precipitate, the sulphate concentration was calculated as a percentage of the formula weight of $BaSO_4$.

The sulphate concentration of water was calculated using the following formula

Sulphate concentration as mg/l of Ba_2SO_4= mg BaSO4 x 411.5ml of sample

10)TITRIMETRIC DETERMINATION OF WATER ACIDITY

The acidity of water samples was determined as follows;

- 50 ml of the water sample was pipetted into a conical flask
- 2-3 drops of phenolphthalein indicator were added to the sample
- 0.02 N sodium hydroxide was prepared and filled into a well-rinsed burette
- It was used to titrate the water samples till a faint pink colour developed in the solution (titration endpoint)
- The volume of titrant used was recorded as V_2 (ml)

Total Acidity= (V_2 x N X 50 X 1000)/ (Sample Volume)

11) TITRIMETRIC DETERMINATION OF ALKALINITY OF WATER

The alkalinity of water was determined as follows;

- 0.1 HCL was prepared by measuring 4.3ml of HCL with a 5ml measuring cylinder and diluting it to the mark in a 500ml volumetric flask.
- The prepared HCL sample was transferred into a well rinsed 50ml burette
- 100ml of water sample was measured using a measuring cylinder into a conical flask
- 3 drops of methyl orange indicator were added to the sample
- It was titrated with 0.1N HCl until the indicator colour changed from yellow to red
- The volume of acid used corresponds to the sum of carbonate and bicarbonates present in an aqueous solution.

Total alkalinity of water was determined as follows;

$$\textbf{Total alkalinity} = \frac{\textbf{Volume of HCl x Normality x 50 x 1000}}{\textbf{Volume of Sample}}$$

RESULTS AND DISCUSSIONS

RESULTS:

The following results were obtained from the physiochemical analysis of potable water in Baham

Table 2*:* Results obtained from the physiochemical analysis of Baham potable water compared with WHO standards.

Parameter	Sample 1	Sample 2	Sample 3	Sample 4	WHO permissible limits
pH	6.11	5.90	5.81	5.39	6.5-8.5
Temperature	20°C	20°C	20.5°C	21°C	< 32°C
Colour	Cloudy	Clear	Faintly cloudy	Clear	Clear
Odour	Disagreeable	Agreeable	Agreeable	Agreeable	Agreeable
TSS (mg/l)	30	10	50	10	25
TDS (mg/l)	20	20	10	14	500-1000
SO_4^{2-}(mg/l)	493.8	370.35	246.9	308.63	250
Cl(mg/l)	7.99	12.99	32.99	22.99	250
Pb(mg/l)	0.28	0.29	0.30	0.27	0.05
Acidity(mg/l)	90	110	60	130	4.5-8.2
Alkalinity(mg/l)	150	50	25	70	200

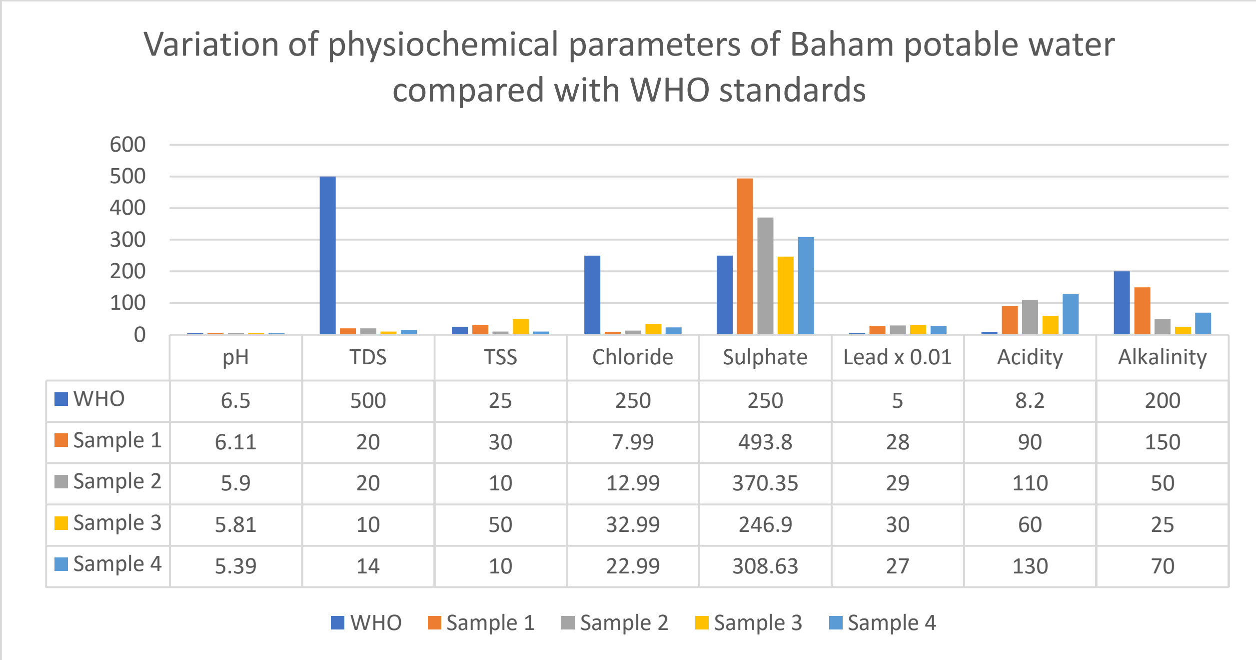
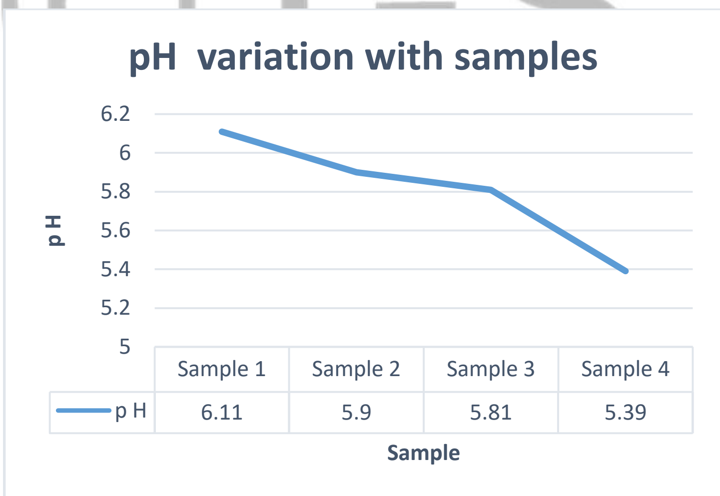


Figure 2: Graph showing the variation of physicochemical parameters of Baham potable water in comparison with WHO standards

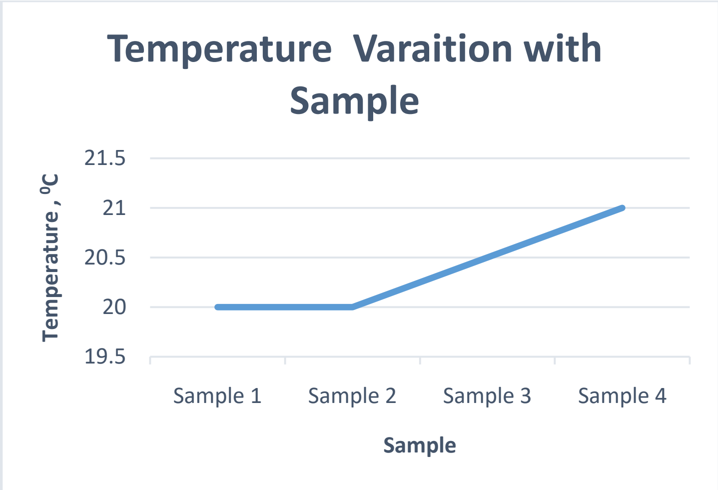
DISCUSSIONS

a) <u>pH</u>



The pH values of all the samples fall below WHO permissible limits. The lowest pH value obtained was 5.39 from sample 4 gotten from the stadium and the highest was 6.11 from the stream. pH values below 6.5 indicate that the water is acidic and is very likely to be contaminated with pollutants making it unsafe for consumption. Water with low pH values corrode water pipes and cause gastrointestinal irritation to highly sensitive individuals according to the World Health Organisation. Baham soil is predominantly lateritic implying it is very rich in insoluble iron; this could be a contributing factor to the low pH values of water samples. Variation of pH with samples is as shown below;

b) Temperature:



All water samples fall with WHO temperature standards. All values were around 20°C which is consistent with the cool and fresh feel of Baham potable water.

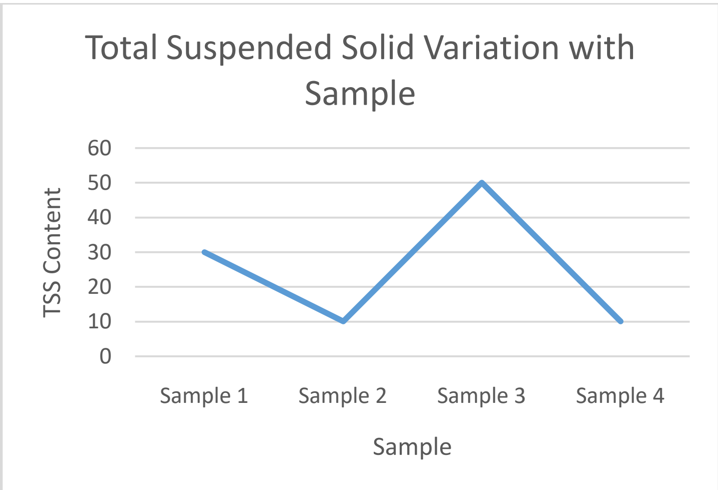
c) Colour:

Samples 2 and 4 were clear but sample 1 had a very cloudy appearance which could be concluded as evidence of contamination. It also mirrors activities carried out at Mafechup stream by the Baham inhabitants such as the washing of clothes and plates. Sample 3 was also found to have a cloudy appearance which makes it aesthetically unpleasant.

d) Odour:

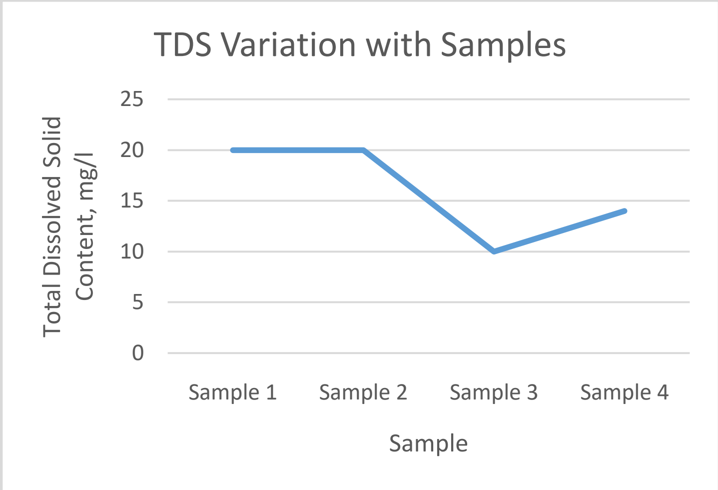
All samples were found to have an agreeable odour but for sample 1.

e) Total Suspended Solids (TSS):



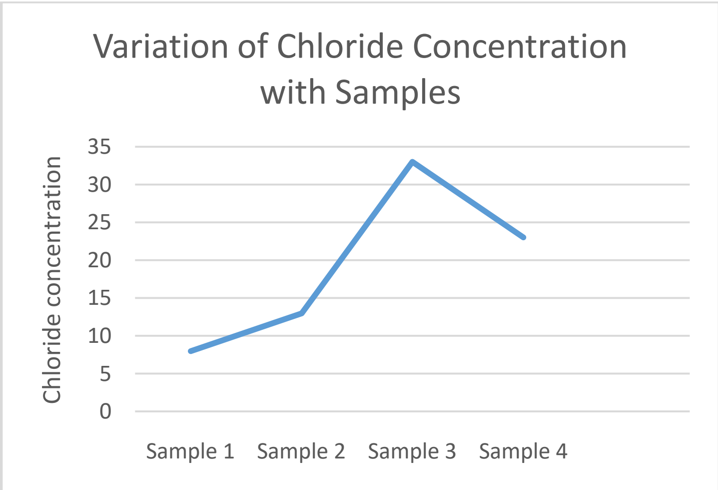
The total suspended solids content of samples 2 and 3 fall within acceptable limits but samples 1 and 3's TSS content were found to be above limits. Sample 3 is an exposed well, hence the high 50mg/l value, which is double the WHO standards come as no surprise. High TSS content decreases the effectiveness of drinking water disinfection agents by allowing microorganisms to "hide" from disinfectants within solid aggregates. These high values indicate that samples 1 and 3 contain high concentrations of bacteria, nutrients, pesticides, and metals. This implies these samples should be filtered before being consumed to remove the suspended solids present in them.

f) Total Dissolved Solids:



The TDS content of all samples is way below WHO standards. Although WHO has concluded that low TDS values have no harmful effects on the body, these results are indicative of the fact that Baham potable water lacks essential minerals. If this lack is not compensated for by a healthy diet, individuals could in the long run suffer from mineral deficiency problems such as a weakened immune system and general fatigue.

g) Chloride Content:



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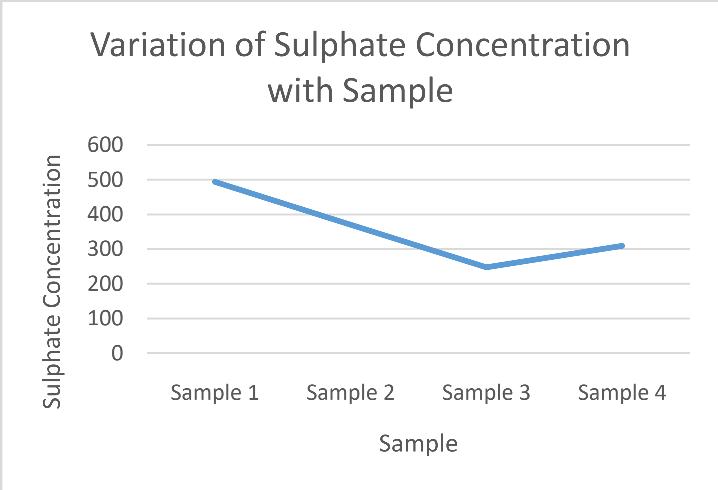
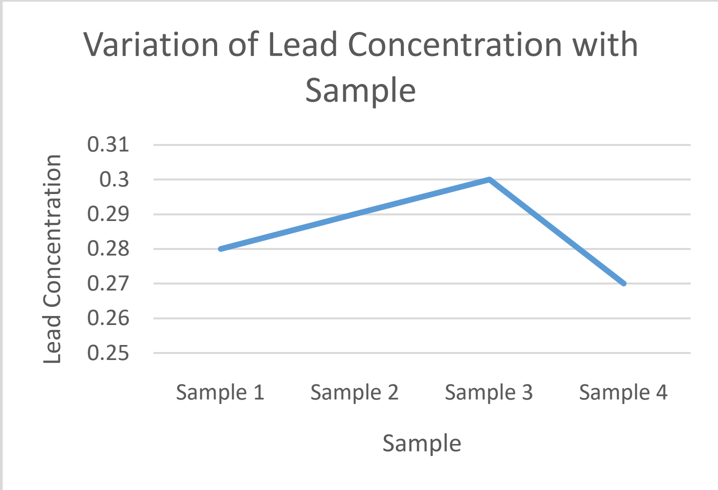
A normal adult human body contains approximately 81.7g chloride. About 530mg/l are lost per day through the process of perspiration. It is recommended that this loss be compensated for through the diet and daily water intake. Baham potable water in the absence of a good diet cannot compensate for this loss as its chloride levels are below WHO prescribed standards. WHO prescribes Chloride levels of about 250 mg per litre of water but all samples have a chloride content of below 33 mg. This also indicates that Baham potable water is not properly disinfected because chlorine is the most important and most common water disinfectant in use today. This explains the prevalence of water-borne diseases in the area.

h) <u>Sulphate:</u>



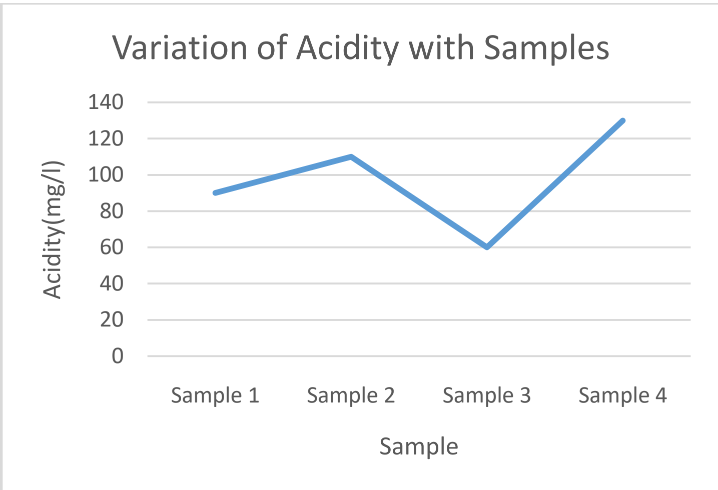
From the analysis, all samples have sulphate contents slightly above permissible limits with the highest being 493.8 mg from sample 1 and 370.35 from sample 2. Sample 1 is boarded by farmlands and Baham is famous for heavy fertilizer use for agriculture so this high sulphate content may be caused by infiltration into the water table by runoffs from farms. Sulphates can also be gotten from the leaching of rocks; sample 2 is surrounded by an enormous array of rocks, which could be concluded as the reason for its high sulphate content. Because of this high sulphate content in Baham potable water, people who come to Baham for the first time with sensitive systems may experience temporary laxative effects. Consuming water with high sulphate content has been attributed to gastritis, diarrhoea, typhoid, high blood pressure, blue baby syndrome, and in the long term, colon cancer. High sulphate containing water may also corrode metal plumbing pipes.

i) <u>Lead:</u>



The results obtained for lead concentration in these samples goes a long way to affirm the conclusions drawn from the pH and sulphate content. The values confirm that Baham water is acidic and its high acid content corrodes the lead distribution pipes. Lead enters drinking water when plumbing materials that contain lead corrode, especially when the water has high acidity and low mineral content (like Baham potable water from the above analysis). All the samples presented values of lead between 0.27-0.30mg/l. These are way above the 0.05mg/l WHO standard. This is very disturbing as the lead in water poses a serious threat to human health. Adults exposed to lead in water can suffer from increased blood pressure and incidence of hypertension decreased kidney functions and reproductive problems in both men and women and even cardiovascular diseases in the long run. Doses of lead that can have little effect on adults may have a significant effect on children since their brains and nervous systems are still developing.

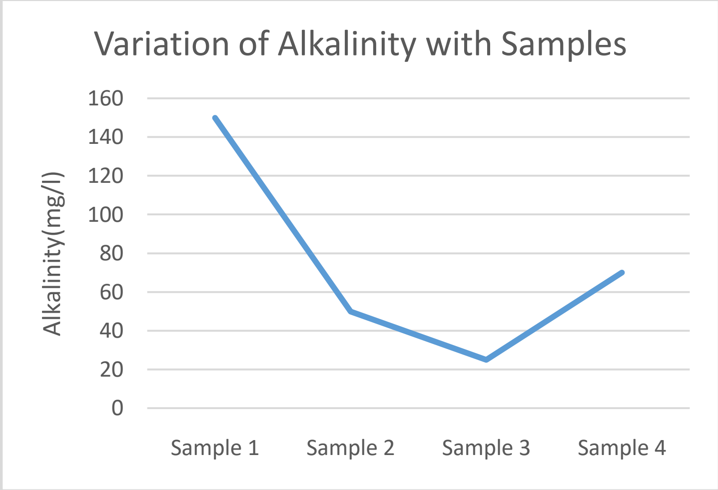
j) <u>Acidity:</u>



The acidity values obtained ranged from 60-130mg/l. They are above the 8.2 WHO limit and they go a long way to confirm the pH values obtained. Analysis shows that the most acidic sample is sample 4-correlative with the pH value analysis wherein it had the lowest pH value.

6

k) Alkalinity:



Analysis has shown that Baham potable water is acidic so it's no surprise that the alkalinity values fall within the WHO permissible limits. The maximum acceptable alkalinity is 200mg/l and the highest alkalinity of our samples is 150mg/l corresponding to sample 1 which has the least acidic pH.

3. CONCLUSIONS

Based on the above physiochemical parameters examined, Baham potable water is not fit for consumption according to WHO standards. It lacks essential minerals which are however compensated for by the diet, it is not properly disinfected and the concentration of lead in water samples is very disturbing. It should be noted that, lead is exceptional in that most lead in drinking-water arises from plumbing in buildings and the remedy consists principally of removing plumbing and fittings containing lead. The 1958 WHO International Standards for Drinking-water recommended a maximum allowable concentration of 0.1 mg/litre for lead, based on health concerns. As a cautioning measure, Lead is a general toxicant that accumulates in the skeleton. Infants, children up to 6 years of age and pregnant women are most susceptible to its adverse health effects. Lead also interferes with calcium metabolism, both directly and by interfering with vitamin D metabolism. These effects have been observed in children at blood lead levels ranging from 12 to 120mg/dl, with no evidence of a threshold. Lead is toxic to the central and peripheral nervous systems, inducing subencephalopathic neurological and behavioural effects WHO (2008).

From the analyses, it was observed that sample 1 is the most contaminated sample with the highest suspended solid concentration, lowest chloride content, and greatest sulphate levels. Sample 3 closely follows sample 1 with the lowest TDS content, high total suspended solids concentration, and the highest lead concentration. Sample 2 meets most of some of the WHO specifications such as colour, odour, temperature, TSS, and alkalinity but has abnormal TDS, chloride, sulphate, and lead concentrations. Sample 4 was found to be the least contaminated water source even though it is the most acidic.

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