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Physicochemical Analysis of Potable Water in Baham Community, Western Region of Cameroon

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ABSTRACT: Safe and easily accessible water is important for community health. This paper presents the physicochemical analysis of water in Baham community, western region of Cameroon by collecting water samples from boreholes, well and stream. Physiochemical analysis using gravimetric and titrimetric methods were carried out on the collected samples and they were analysed based on their temperature, pH, colour, odour, total dissolved solid (TDS) and total suspended solid (TSS), sulphate, lead and chloride concentration as well as acidity and alkalinity. The results showed low pH values 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 between 10-20 mg/l, TSS 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, very low chloride concentration level of 8-23 mg/l compared to WHO's recommended 250 mg/l, very high sulphate contents of 246.9-493.8 mg/l and 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 high acidity (60-110 mg/l) and alkalinity (50-150 mg/l) values 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, not properly disinfected and has disturbingly high lead concentrations.

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Water is an indispensable resource (Sushil *et al*, 2015) occupying about 70% of human body mass and 71% of the earth's surface. It is universally acceptable that water quality is an index of the good health and wellbeing of every society (Arun and Nabin, 2018) hence 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). As a matter of fact, 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 as one of the manifestations of poverty in developing countries (Aminu *et al.*, 2017) and with a fast-rising population, rapid increase in urbanization, industrialization and anthropogenic activities, the rates of surface and ground water pollution are soaring more than ever worldwide (Daud *et al*, 2017; Amanjot *et al*, 2015; Ugbaja and Otokunefor, 2015). 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). Water quality is so core to WHO's heart that; "Ensuring availability and sustainable water management and sanitation for all" is Goal Six on its 2030 agenda for sustainable development. Any alteration beyond the permissible range in the set standards makes water polluted and unfit for any purpose for which it is intended. It is for this cause that regular monitoring and analysing of water is essential to evaluate its quality or degree of pollution (Sadiya *et al.*, 2018). Hence, the objective of this paper is to evaluate the physicochemical characteristics of

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Potable water in Baham community, Western Region of Cameroon.

MATERIALS AND METHODS

Study Area: 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 an approximate population size of about 60,000 persons. It is made up sixteen villages and it is bordered by Banjoun, Bayangam, Bahouan, Bamendjou, Bapa, Batie, Badenkop and Bangou, Cameroon.

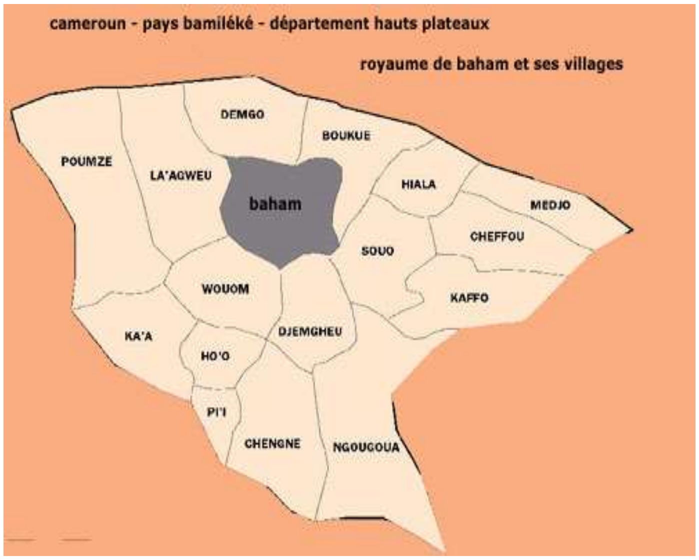


Fig 1: Map of Baham and its 16 villages (Baham Council, 2021)

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 1.5 ml 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.

Table 1: Water sampling points.

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

Source: Fieldwork (2021)

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, Erlenmeyer's flasks, burette, dropper potassium chromate indicator, silver nitrate solution, distilled water, concentrated sulphuric acid, concentrated hydrochloric acid, phenolphthalein and methyl orange indicators and 0.02N sodium hydroxide.

Determination of 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 in order 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.

Determination of 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.

Determination of Colour: Visual observation for any noticeable colour.

Determination of Odour: After sample collection, 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 observing by placing nostrils close to bottle neck and perceiving the released smell (sample was at room temperature).

Gravimetric Determination of Total Dissolved Solids in Water (TDS), [IS: 3025 (Part 16)]. A 50 ml of the water sample was transferred into a measuring cylinder. It was filtered through a 250 mm 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;

$$TDS\ (^{mg}/_{l}) = \frac{(WDS + CF) - (WF)}{Volume\ of\ sample\ used}$$

Where: WDS = weight of dry solid; CF = conical flask; WF = weight of flask

Gravimetric 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:

$$TSS\ = \frac{(WFP + R) - (WFP)}{Volume\ of\ sample\ used}$$

Where R = residue; WFP = weight of filter paper

Titrimetric Determination of Chloride Content in Water by the 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 1000 ml 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 end point. 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:

$$Cl\ (^{mg}/_{l}) = \frac{(V_1 - V_2)\ \times\ N\ \times 34.45\ \times A}{V_3}$$

Where: A = 1000 ml sample; V_1= Volume in ml of silver nitrate used in the solution; V_2= Volume in ml of silver nitrate used in the blank titration; V_3= Volume in ml of sample taken for titration; N= Normality of silver nitrate solution.

Gravimetric 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 into it. The mixture was heated in a water bath for 30 minutes. The beaker was left to cool for about 15 minutes. 100 ml 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.

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 411.5 ml of sample

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 end point)
-The volume of titrant used was recorded as V_2 (ml)

$$Total\ Acidity = \frac{V_2 \times N \times 50 \times 1000}{Sample\ Volume}$$

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 500 ml 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 aqueous solution. Total alkalinity of water was determined as follows;

$$Total\ Alkalinity = \frac{Vol.of\ HCl \times N \times 50 \times 1000}{Sample\ Volume}$$

Where N = normality; Vol. = volume

RESULTS AND DISCUSSIONS

The physiochemical analysis of potable water in Baham community in Western Cameroon was assessed and the results are presented in figure 2. Several physicochemical parameters such as pH, temperature, alkalinity, acidity, total dissolved solids, total suspended solids, chloride, sulphate and lead were evaluated.

pH: Freshwater pH varies across the world depending on weather patterns, human activity, and natural processes. Water with a very low or high pH can be a sign of chemical or heavy metal pollution. Water that doesn't fall in the "safe" pH range of 6.5 to 8.5, particularly if it's alkaline, isn't necessarily unsafe. However, very alkaline water can have an unpleasant smell or taste, and it can also damage pipes and water-carrying appliances. Acidic water with a pH of less than 6.5 is more likely to be contaminated with pollutants, making it unsafe to drink. It can also corrode (dissolve) metal pipes. Many municipal water suppliers voluntarily test the pH of their water to monitor for pollutants, which may be indicated by a changing pH. When pollutants are present, water companies treat their water to make it safe to drink again. The pH value of the Baham community potable water ranged (Table 2) from 5.39 – 6.11 with a mean of 5.80 and standard deviation of 0.30. These values are within the WHO value of 6.5.

Temperature: All water samples (figure 4) fall within WHO temperature standards. All values were around 20°C which is consistent with the cool and fresh feel of Baham potable water.

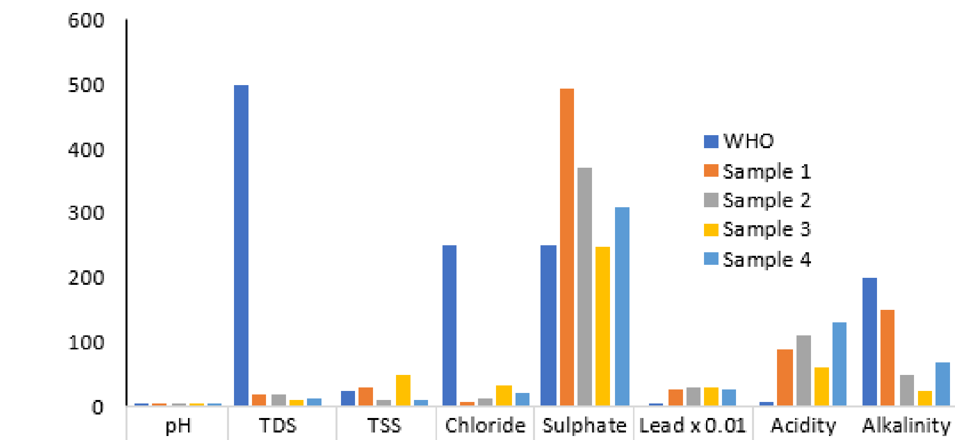
Colour: Samples 2 and 4 were clear but sample 1 had a very cloudy appearance which could be concluded as evidence of contamination. It also mirrors activities carried out at Mafechup stream by the Baham inhabitants such as washing of clothes and plates. Sample 3 was also found to have a cloudy appearance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

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

Total Suspended Solids (TSS): The total suspended solid content of sample 2 and 3 fall within acceptable limits but samples 1 and 3's TSS content were found to be above limits (figure 2). Sample 3 is an exposed well hence the high 50mg/l value, which is double the WHO standards (Aktar *et al.*, 2017), comes 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. It implies that these samples should be filtered before consumed in order to remove the suspended solids present in them.

Total Dissolved Solids: The TDS content of all samples are way below WHO standards (Aktar *et al.*, 2017) as presented in figure 6 above. Although WHO has concluded that low TDS values have no harmful effects to 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.

Chloride Content: A variation of chloride concentration in the samples is presented in Table 2. 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 through 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.



	pH	TDS	TSS	Chloride	Sulphate	Lead x 0.01	Acidity	Alkalinity
WHO	6.5	500	25	250	250	5	8.2	200
Sample 1	6.11	20	30	7.99	493.8	28	90	150
Sample 2	5.9	20	10	12.99	370.35	29	110	50
Sample 3	5.81	10	50	32.99	246.9	30	60	25
Sample 4	5.39	14	10	22.99	308.63	27	130	70

Fig 2: Variation of physiochemical parameters of Baham potable water in comparison with WHO standards.

Table 2. Statistical data analysis of the physicochemical variation of Baham potable water

	pH	TDS	TSS	Cl	So4	Pb	Acidity	Alkalinity
Sample 1	6.11	20	30	7.99	493.8	28	90	150
Sample 2	5.9	20	10	12.99	370.35	29	110	50
Sample 3	5.81	10	50	32.99	246.9	30	60	25
Sample 4	5.39	14	10	22.99	308.63	27	130	70
Total	23.21	64	100	76.96	1419.68	114	390	295
Mean	5.8025	16	25	19.24	354.92	28.5	97.5	73.75
STD	0.302366	4.898979	19.14854	11.08678	105.4148	1.290994	29.86079	54.06401

Sulphate: Sulfate (SO_4) can be found in almost all natural water. The origin of most sulfate compounds is the oxidation of sulfite ores, the presence of shales, or the industrial wastes. Sulfate is one of the major dissolved components of rain. High concentrations of sulfate in the water we drink can have a laxative effect when combined with calcium and magnesium, the two most common constituents of hardness. Bacteria, which attack and reduce sulfates, form hydrogen sulfide gas (H_2S). The maximum level of sulfate suggested by the World Health Organization (WHO) in the Guidelines for Drinking-water Quality, set up in Geneva, 1993, is 500 mg/l. EU standards are more recent, 1998, complete and strict than the WHO standards, suggesting a maximum of 250 mg/l of sulfate in water intended for human consumption. The sulphate concentration (Table 2) of the study area is (246.9 – 493.8) ± 354.42

Lead: The results obtained for lead concentration in these samples (Table 2) goes a long way to affirm the conclusion drawn from the pH and sulphate content. The values confirm that Baham water is acidic in nature 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 above analysis). All the samples presented values of lead between 0.27-0.30 mg/l. These are way above the 0.05 mg/l WHO standard. This is very disturbing as 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 which can have little effect on adults may have significant effect on children since their brains and nervous systems are still developing.

Acidity: The acidity values obtained (Table 2) 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.

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 (Table 2). 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.

Conclusions: Based on the analysis of the abovementioned physiochemical parameters, it has been established that Baham potable water is not fit for consumption according to WHO standards. It lacks essential minerals; it is not properly disinfected and the concentration of lead in water samples is very disturbing. The findings have been presented to the municipal authorities to appropriately address these issues as this may lead to a public health disaster in the community if not properly handled.

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