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Physicochemical and Chronological Profile of Stream Water Sample from Idim Afaha Ikot Ebak in Essien Udim Local Government Area, Akwa Ibom State

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Abstract

The water samples were taken from Afaha stream, located in Essien Udim Local Government Area of Akwa Ibom State. The following physicochemical parameters and microbiological profile were analysed: pH, temperature, salinity, electrical conductivity, total dissolved solids, total soluble solids, biochemical oxygen demand, dissolved oxygen, total alkalinity, total acidic contents, total heterotrophic bacterial count and total heterotrophic fungal count. The results obtained indicated that there were changes in the parameters so analysed in the steam water while there were no significant changes in those of the commercial water. The pH increased from 6.55±0.06 to 6.75±0.01. Other parameters such as TA. TAC, DO, TDS, TSS, EC and BOD were found to be decreasing in the case of the stream water stored in the clay pod.

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Introduction

Drinking or portable water is that which is safe for consumption. Water is an important item needed for health, productivity and economic development (Pantil *et al.*, 2023). The scarcity of good quality drinking water is a universal problem due to poor and inadequate sanitation practices. Its consumption is linked to many human illnesses (WHO, 2005). Drinking water quality can be accessed through physicochemical properties (pH, temperature, appearance, turbidity, alkalinity, total acidity and total dissolved solids) and microbiological properties.

The government cannot provide drinking water to the entire masses due to problems like broken down facilities, the high cost of installation of new ones, poor economic policies, and climate change (Shamsudeen, 2023). Alternative sources of drinking water are streams, boreholes, and rivers. Most of the sources hold impure water which is detrimental to human health when consumed. To obtain good-quality water from these sources they are held in plastic, enamel, and metal tanks for purification before consumption (Hill, 2019).

Impure water may be disinfected, ozonized, treated with ultraviolet light, and membrane filtered, along with other processes such as coagulation, flocculation, sedimentation and filtration. This can be done singly or in combination to obtain drinking water qualities that meet the standard physicochemical and microbial level limits (Addisie, 2022). Evaluating Drinking Water Quality Using Water Quality Parameters and Esthetic Attributes. Air, Soil and Water Research Volume 15: 1-8). Water qualities are set, regulated and monitored by Government Agencies of countries such as The National Agency for Food and Drug Control (NAFDAC), the Environmental Protection Agency (EPA), and the World Health Organization (WHO) etc to protect consumers from toxic effect of chemical pollutants and infection of microbial species.

All these methods are costly and complex to be afforded by the poor household due to limited funds and low levels of awareness. Therefore traditional methods for the provision of these good quality drinking water are being investigated. For instance, Shamsudeen (2023) assessed the physicochemical quality of domestic drinking water stored in clay pots in Birin Kebbi, Nigeria. Ali (2012) suggested the development of an affordable source of water supply infrastructure for the poor households in Nigeria, its challenges and prospects.

The red clay pot is a traditional method of storing drinking water (Shamsudeen, 2023). The clay pot is cast from the earthen clay material. Clay pot has high porosity thereby having adsorption and sedimentation potential according to Ficks Law Equation 1.

$$J = \frac{-Ddc}{dX} \quad \text{-----------------------------} \quad 1$$

where J is the flux (the rate of diffusion), D is the diffusion coefficient, C is the concentration, and X, the distance it passes through the membrane. The high porosity sets up a gradient of concentration of impure particles towards the region of low concentration (D) until the water is purified to the level that is determined by the period of storage. This work investigated water perception that the red clay pot can purify the impure water into a good drinking quality standard comparable with the commercial and World Health Organization (WHO) standards.

Portable water is traditionally stored in different ways for purification (Obeta, 2018). Clay pot is made of clay which contains silica, aluminum, and potassium. According to (Shamsudeen, 2023) it is the mineral content that determines its absorption capacity or ability to trap and hold the impurities. The oxide content reacts with other impurities in the water and removes them. Calcium and magnesium affect the taste and appearance.

The use of clay pots is an old and familiar method (Hill, 2019). The method was perceived to purify impure water quality to portability level (Yasin *et al* ., 2015). Hence, a scientific study into the improvement of the physicochemical and microbial quality of stream water was undertaken. The outcome of the study is expected to renew the old craft of clay pot production and provide employment while providing safe water for the population.

Materials and methods

The water samples were harvested at the same spot from the stream at the same time from Idim Afaha Ikot Ebak in Essien Udim Local Government Area of Akwa Ibom State, Nigeria. Standard reagents and methods were used to determine the physicochemical parameters and microbiological profile of the water samples. In these, ten (10) liters of the water sample were stored in three (3) clean clay pots that stood on dry sharp sandy soil in a medium size enamel basin and covered with lids made of the same materials. Samples from each of the setups were taken every five (5) days and analyzed for their physicochemical and microbiological properties. Commercial water samples were collected from the same production line/date and analyzed in the same way as that of the stream water. Data from both samples were compared base on those parameters for their suitability for human consumption.

Results and Discussion

Table 1 shows the physicochemical parameters of stream water in comparison with commercial water samples and the WHO standards. According to the table, the pH of the stream water increased from 6.55 to 6.75 from day zero to day 24, and from 6.63 6.93 in the commercial water sample from day zero to day 24 respectively. The stream water sample temperature increased from 25.25 to 21.02ºC, while that of the commercial water sample remained almost constant.at 25.05ºC. The salinity of the stream water sample decreased from 550.00 mg/L to 533 mg/L from day 0 to day 24 respectively. While the CW sample value of the parameter remained content throughout the experiment 540.00 mg/L. The electrical conductivity of the SW increased gradually from 501.00 µS/cm to 411.00 µS/cm from day 0 to day 24, the parameter in the CW remained constant at 556.00 µS/cm. The TDS of the SW decreased from 701.11 mg/L to 490.12 mg/L from day 0 to day 24.

Total suspended solids (TSS) indicate suspended organic and inorganic solids in water. TSS impacts turbidity, which can interfere with disinfection and filtration, including taste. In the study, TSS in the SW sample stored in a red clay pot decreased from 105.10 - 15.00 between day 0 to day 25 of storage. The parameter in sachet water remained constant during the same period of storage. The difference in the values of the parameter is attributed to the porosity of the clay pot which enhanced the gradient and sucking potency of the particles towards the walls of the pot, the values approached the WHO maximum of 500 mg/L though some counties have more stringent values.

Biological oxygen demand (BOD) measures the amount of oxygen dissolved per unit volume of water. WHO fixes a limit of 30.00 mg/L of potable water, but may vary according to the source of water. In the study, the initial value of the parameter in SW, 59.03 decreased to 10.01 mg/L in day 24. The sample decreased below the most stringent value of WHO. The CW value remained constant; there was no sufficient sedimentation and diffusion of the content through the barrier cellophane bag. The DO is the volume of dissolved oxygen in portable water; the value can be affected by temperature, pollution, and sunlight. WHO sets the limit at approximately 5.00 mg/L in portable water, the values limit differs among countries. Low levels of the parameter produce hydrogen sulphide, producing foulness in the water while high levels can cause corrosion on metal water containers. in this study, the SW showed 13.75 mg/L of the parameter. A sufficient value of DO is needed for good health in drinking water.

Total alkalinity (TA) is an important indicator of good quality portable water. The water can neutralize the acid. The presence of carbonates, bicarbonates, hydroxides and others impacts TA in portable water. The general range of TA in portable water is set at between 40 – 150 mg/L to guarantee the safety and quality of potable water.

The total acidity capacity (TAC) of water indicates its ability to neutralize an acid. The safe limit for the parameter is between 0.60 to 1.00, every unit of alkalinity needs 0.61 – 1.00. The study shows the decreasing value of the parameter to the safe level.

Table 1: Physiochemical Quality of Stream Sample Stored in Clay Pot

Days	Day 0	Day 4	Day 8	Day 12	Day 16	Day 20	Day 24
pH (SW)	6.55±0.06	6.57±0.11	6.59±0.04	6.65±0.02	6.66±0.03	6.75±0.01	6.75±0.01
pH (CW)	6.93±0.60	6.93±0.60	6.93±0.70	6.93±0.60	6.83±0.60	6.93±0.60	6.93±0.60
Temp ºC (SW)	25.25±0.3	25.34±0.03	24.02±0.23	22.72±0.23	25.02±0.23	21.02±0.23	21.02±0.23
Temp ºC (CW)	25.05±0.4	25.02±0.23	25.02±0.23	25.02±0.23	25.02±0.23	25.02±0.23	25.02±0.23
Sal. (mg/L) (SW)	550±0.01	546±0.04	540.00±0.04	532±0.04	532±0.04	533±0.34	533±0.34
Sal. (mg/L) (CW)	540±0.21	540±0.14	540.00±0.04	541±0.24	540±0.04	540±0.14	540±0.14
EC µS/cm (SW)	501±0.10	513±0.50	491±0.10	402±0.12	402±0.15	411±0.17	411±0.17
ECµS/cm (CW)	556±0.10	556±0.20	556±0.20	556±0.10	556±0.30	556±0.11	556±0.11
TDS (mg/L) (SW)	701.11±0.11	689.10±0.11	674.00±0.14	672.11±0.01	5901±0.51	490.12±0.11	490.12±0.11
TDS (mg/L) (CW)	101.11±0.11	102.11±0.11	101.11±0.21	101.11±0.11	101.11±0.11	101.11±0.11	101.11±0.11
TSS (mg/L) (SW)	105.10±0.40	85.30±0.10	67.20±0.30	56.50±0.20	25.00±0.00	15.00±0.31	15.00±0.31
TSS (mg/L) (SW)	25.00±0.10	25.00±0.10	25.00±0.10	25.00±0.10	25.00±0.10	25.00±0.10	25.00±0.10
BOD (mg/L) (SW)	59.03±0.12	50.03±0.12	39.03±0.12	20.03±0.12	15.03±0.12	10.01±0.12	10.01±0.12
BOD (mg/L) (CW)	3.10±10	3.10±11	3.11±20	3.11±00	3.10±11	3.10±11	3.10±11
DO (mg/L) (SW)	3.75±0.00	5.75±0.10	6.65±0.10	7.75±0.22	10.00±0.00	13.75±0.202	13.75±0.202
DO (mg/L) (CW)	5.80±0.02	5.81±0.02	5.84.00±0.02	5.80±0.12	5.92±0.12	6.80±0.10	6.80±0.10
T. Alk (mg/L) (SW)	254.00±0.21	225.00±0.31	220.00±0.21	210.00±0.31	190.00±0.01	191.00±0.11	191.00±0.11
T. Alk (mg/L) (CW)	200.00±0.01	200.00±0.01	200.00±0.01	200.00±0.01	200.00±0.01	200.00±0.01	200.00±0.01
TAC (mg/L) (SW)	200.00±0.90	200.00±0.90	200.00±0.90	200.00±0.90	200.00±0.90	100.00±0.10	100.00±0.10
TAC (mg/L) (CW)	200.00±0.20	200.00±0.20	200.00±0.50	200.00±0.60	200.00±0.80	198.00±0.90	198.00±0.90

Note: SW = stream water, CW = commercial water

Table 2 shows the total heterotrophic bacterial count of SW and CW before and after storage in different containers in the same environment. According to the table, the bacterial colony count in SW decreased from 120 cfu/L to 147 cfu/L between day 0 to day 24 in the clay pot while the CW level staggered between 4 and 5 cfu/L. The observation in the stream water suggested that the porosity of the clay pot might have introduced a suction effect on the microbial cells thereby binding them to the crevices of the clay surface according to Fick's Law.

Table 2: Total Heterotrophic Bacterial Count

Samples	Day 0	Day 4	Day 8	Day 12	Day 16	Day20	Day24	WHO **cfu/L)**	**(std)**
SW **(cfu/L)**	120	118	116	151	149	146	147	0	
CW **(cfu/L)**	5	4	4	5	5	6	6	0	

Table 3 shows the total heterotopic fungal count of the SW and CW which were torn in clay pot and cellophane bag for 24 days respectively. The initial SW value of 35 cfu/L decreased to 30 cfu/L while the CW staggered in colony forming count between 5 to 8 against the 0 limits of WHO (2006)

Table 3: Total Heterotrophic Fungal Count

Samples	Day 0	Day 4	Day 8	Day 12	Day 16	Day 20	Day 24
SW **(cfu/L)**	35	35	34	34	37	37	34
CW **(cfu/L)**	5	5	5	3	6	4	5
WHO **(cfu/L)**	0						

WHO (2004) **standard (0 cfu/L)**

Discussion

Major health problems in the human community are linked to the ingestion of unsafe water (WHO, 2006, Mabvouna, 2020). Unsafe water could be microbiological (bacteria, viruses and protozoan) contamination in conjunction with some chemicals above the permissible limits. The physical parameters of water are related to the esthetics of the water which may impede its consumption, (Ukpe, 2023).

Based on the results so obtained, the pH of the water from the clay pot increased from 6.55±0.06 to 6.75±0.01. This is in line with the upper limit of WHO (2006) and lower than the value of the commercial water sample which remained constant from day 0 to day 24 at 6,93

The ability of drinking water to conduct electricity under the influence of a potential difference is called electrical conductivity. The parameter has a positive association with TDS, TSS and TAC. They also affect the taste and odour of water. The value should be maintained at its minimum level since low EC or soft water though pleasant on the palate, can leach metal materials into the water and high of soft water on the whole, TAC and pH are the two important parameters to look out for in safe drinking water (WHO, 2006)

The limit of DO for drinking water is 5.0 mg/L for agricultural use. A very low value of DO may result in anaerobic conditions, giving rise to the development of bad odour and other organoleptic attributes. In this work, the DO of the stream water stored in a red clay pot reached the value at the end of the storage period.

The temperature of drinking water also has an important effect on the health of the consumers. Cold water can lead to hypothermia, and heat-related, if it is hot. (Meride, 2015). The clay pot water attended the high limit 50°F and 70°F temperature. The result agreed with that of the WHO standards. Since the human body can adjust to slight temperature changes, the parameter may not pose a problem, but the exposure should be with moderation.

Total suspended solids or nutrients promote the growth of microorganisms in the drinking. It is a standard method of measuring the wholesomeness of drinking water. The parameter can affect the taste, smell and turbidity of the water. High levels of TSS may indicate the unsuitability of the water for consumption and may result in gastrointestinal problems for the consumers (WHO, 2006). The value obtained from that of the clay pot sample was low compared to the standards.

The EPA threshold of the parameter in drinking water is set at 500 mg/L. The parameter indicates the concentration of organic (vegetables) and inorganic calcium, magnesium, sodium, chloride and sulphate) material dissolved in a drinking water sample. Apart from the health implications of consuming high-value TDS water, the organoleptic values of the sample may be compromised.

Total alkalinity indicates the concentration presence of alkaline compounds such as carbonates, bicarbonates and hydroxides present in drinking water. The optimum concentration of the parameter in drinking water is 40-120 mg/l or 30 to 400 ppm (Khan, 2013). Higher and lower levels of the parameter in drinking water can cause introduce taste problems while total acidity measures the acid content of drinking water and exhibits a similar effect in water and consumers (Meride, 2015). The microbial (bacterial and fungal) population of water samples stored in the clay pot showed some reduction in the number colony colony-forming units as the number of days of storage increased. The commercial water samples showed a constant level of microbial contamination approaching the optimum value of 0 cfu/L of WHO, (2006) since no microorganism should be allowed in drinking water. High concentrations of bacteria and fungi may pose health problems to the consumers.

Conclusion

The important physicochemical parameters of the stream water stored in the red clay pot decreased from day one to the final day of storage. The commercial water sample showed almost no changes in the important physicochemical parameters throughout the storage period. The microbial load in both cases exhibited a similar trend in their reduction at the end of the end of the investigation. Therefore, it could be concluded that the red clay pot could be useful in the production of good quality drinking water at low quantities for domestic use.

The production of red clay pots should not be abandoned because it could provide employment and good health through good drinking water.

Conflict of Interest

The authors have no relevant financial or non-financial interests to disclose

Contribution of the Authors

The work was designed by Dr Patrick G Udofia and Dr. Richard Ukpe. The initial draft was written by the two authors while all the authors were involved in the bench work.

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