Environment Protection Engineering

Vol. 50 2024 No. 3

DOI: 10.37190/epe240309

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EVALUATING SOCIO-CULTURAL INFLUENCES ON THE NUBUI RIVER QUALITY AND UTILISATION IN GHANA

Clean water plays an important role in ensuring good public health and reducing health risks. To ensure population well-being, clear quality guidelines and standard limits are set to protect water resources. Drinking water should be free of microbial and chemical contamination, with water quality index values between 70 and 100. Despite meeting these standards, socio-cultural values deeply influence the relationship between rural communities and their water resources. Aesthetic, chemical and microbial water quality parameters including pH, turbidity, colour, TDS, nitrate and phosphate content, *Escherichia coli* and *Salmonella* levels were assessed; these parameters were used in computing water quality indices. Field observations were also done throughout the sampling season as water samples were assessed. Key informant interviews were conducted among ten purposively sampled community leaders, using an in-depth interview guide; the results were analysed using the interpretative phenomenological analysis method. Subsequently, a descriptive cross-sectional observational study involving 338 respondents was conducted to assess public perceptions regarding water quality, utilization types and socio-cultural influences. Water quality is compromised by run-off from riparian agricultural activities and domestic, coupled with seasonal aesthetic issues. Cultural norms and history influenced the

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acceptance, utilization, and protection of the water resource. Proper community engagement is necessary to curb any socio-cultural barriers to water utilisation and protection interventions in rural communities.

1. INTRODUCTION

Clean water is a major public health determinant globally [1]. However, its quality and quantity have been deteriorating due to climate change, rapid urbanization, extensive industrialization, and other anthropogenic activities [2, 3]. In the past decades, these changing lifestyles led to the disposal of emerging contaminants (ECs) such as personal-care products, pharmaceuticals, pesticides, and heavy metals into the environment causing global public health concerns [4]. These public health concerns have become exacerbated by the fact that rural communities still lack access to clean water, and depend on untreated sources of water, including surface and rainwater for drinking and other domestic purposes [5].

According to the World Health Organization, 663 million people are using water that does not meet the standards for human consumption [6] and contaminated water is responsible for one-third of mortalities in developing nations and over 80% of diseases worldwide [7]. Low- or middle-income countries (LMIC) are among the most vulnerable countries, whereby insufficient water causes 60% of diarrhoea mortality in these regions [8]. Simple household interventions, such as slow sand filtration and a nano filter [9], ceramic pot filtration, and solar disinfection treatment approaches, offer point-of-use water treatment solutions focused on improving the quality of water in homes [10, 11]. These techniques are appropriate, to achieve removal of specific organic and inorganic pollutants in water [12], to improve water quality for drinking and other domestic purposes and to reduce associated health risks.

Water is one of the main routes of human exposure to various pathogens and chemicals, this phenomenon plays a key role in influencing their sense of risk of exposure to waterborne diseases such as cholera, diarrhea, typhoid, skin infections, conjunctivitis, dysentery, and hepatitis A [13]. Due to apparent health risks because of unsafe drinking water, there are clear guidelines and pollution limits established to safeguard the health of populations [14]. This suggests that drinking water should be free of disease-causing agents, meet water quality indices values approximately between 70–100 and have aesthetical quality including good taste, colourless and odourless, as this has direct influences on its acceptance by consumers [15].

Several studies suggest that water users' perception of water aesthetics is a major driver of individual choices of drinking water, be it safe or unsafe water [16, 17]. Therefore, any deviation in aesthetic quality can potentially lead to rejection, particularly for drinking purposes [17]. Meaning, that with aesthetic quality requirements met, consumers can accept and perceive the water safe. Thus, addressing aesthetic issues is important

but the pending question is, what about if the water is not safe, yet palatable and acceptable. While the aesthetic appeal of water is potentially a major determinant of utilisation among rural populations, there may be other factors reinforcing aesthetic appearance and utilisation, this gap was identified in a proposed framework for rural remote communities by Hu et al. [17].

Previous socio-hydrological studies also indicate that the relationship between rural communities and their environment, vis-à-vis water resources is deeply rooted in socio--cultural values and norms [18]. This was further reiterated by Rangecroft et al. [19] that, understanding the relationships between people and water can be supported by perceiving data and traditional ecological knowledge on water quality. This will facilitate the formulation of locally appropriate sustainable strategies for water resource management. Undoubtedly, sociological and cultural factors play a significant role in shaping the acceptance and usage of water resources. However, these factors have been inadequately addressed in previous research studies [16, 20]. Recognizing the influence of socio-cultural dynamics, Wasonga et al. [20] advocated for a comprehensive ethnographic investigation to fully comprehend the factors influencing perceptions of water quality and utilization patterns. Thus, this study delved into the socio-cultural factors influencing the utilization, acceptance, and quality assessment of surface water in rural, remote communities, employing an exploratory sequential mixed-method approach. The study commenced with field observations and laboratory analysis of water samples, followed by ethnographic qualitative methods, and culminated in a cross-sectional observational survey to enhance the triangulation of findings.

2. MATERIALS AND METHODS

Description of the study area. The study was conducted in the Volta region of Ghana, within five sub-communities (Helu, Woe, Hloma, Ahor, Amele) in Fodome. Figure 1 shows selected communities approximately 100 m from the Nubui River and abstraction sites. For this study, the selection of communities was based on their proximity to the abstraction points, dependence on the water source and anthropogenic activities close to the water source.

Fodome is a traditional area under the Agumatsa sub-district located in the Hohoe municipality of the Volta Region. Fodome is located at longitude 6°52′0″ North and latitude 0°17′0″ and shares a border with Togo on the east, southeast by the Afadzato district, southwest with Kpando municipal, North of Jasikan district. Fodome traditional area has a total of 14 sub-communities namely: Agbetsido, Dzorkpe, Fodome Agbesia, Fodome Agorxoe, Fodome Ahor, Fodome Amele, Fodome Ando No. 1, Fodome Ando No. 2, Fodome Dzogbega, Fodome Helu, Fodome Hloma, Fodme Woe, Kodzeto and Tomegbe. The people of Fodome are mainly Ewes who are multi-religious, Islam, Christianity, and Traditional religion. The population of Fodome is estimated to be 9190, with the

majority of the inhabitants being farmers. The sources of water for the inhabitants are mechanized boreholes, sachet water and a stream (Nubui) that flows through most of the communities.

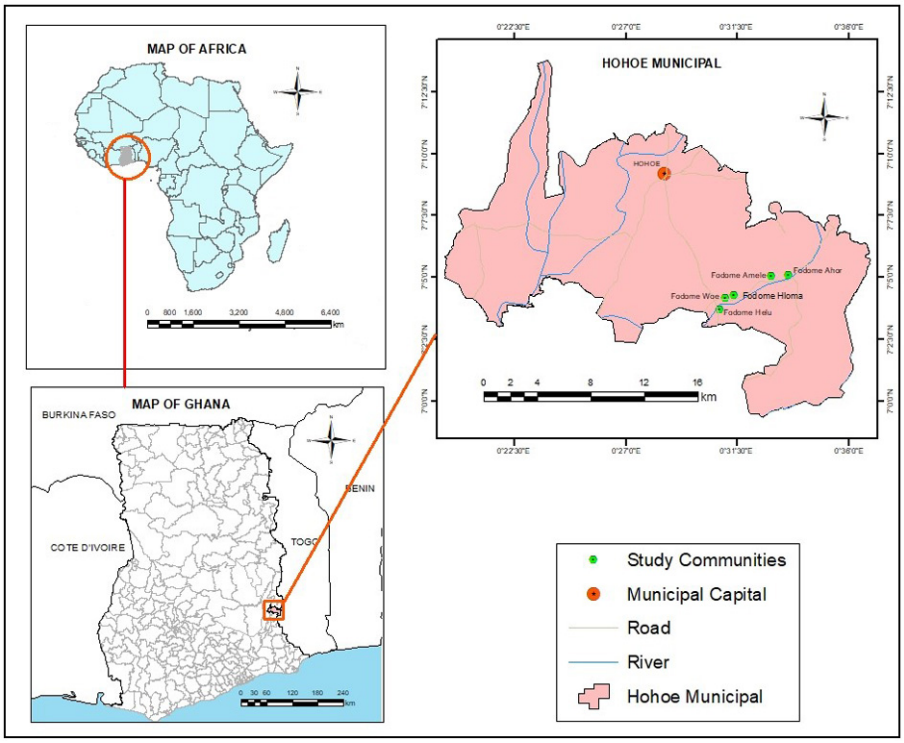

Fig. 1. Map of studied communities and water sampling points

Water quality analysis. For water quality analysis, 25 samples were collected per month with a total of 275 water samples throughout 11 months of the sampling period. Samples were analysed for physicochemical parameters (turbidity, colour, pH, dissolved oxygen (*DO*), total dissolved solids (*TDS*), nitrates and phosphates) as well as microbial content (*E. coli* and *Salmonella* sp.). Before the analyses, instruments were calibrated according to the manufacturers' guidelines. For physicochemical analyses, pH and *TDS* were measured using a multi-parameter ion-specific meter (EZDO 7200 multimeter), while *DO* were measured using a DO meter by the diaphragm electrode method. Turbidimeter Model 2100P (Hach, UK) was used for turbidity measurements and a platinum cobalt standard method was used for the determination of the colour intensity of the collected samples. Nitrate and phosphate ions were analysed using standard methods [21]. For bacterial content, a membrane filtration technique was used.

Water samples were plated on a specific media for both *E. coli* and *Salmonella typhimurium.* The plates were later incubated under aerobic conditions for 24 h at 37 °C.

Water quality indices. The Canadian Council of Ministers of the Environment Water Quality Indices (CCME WQI) offers a simple mathematical model for calculating the index value, which aids users in assessing the state of a water body's health. The method is based on three significant factors (scope, frequency, and magnitude) dependent on the water's intended usage, to provide a single unitless number that represents the overall quality of the water [23].

The measure for scope is F_1. It means the number of variables whose objectives are not met (failed variables), relative to the total number of variables measured

$$F_1 = \frac{\text{Number of failed variables}}{\text{Total number of variables}} \times 100\%$$

F_2 (frequency) is the frequency by which the objectives are not met (failed tests)

$$F_2 = \frac{\text{Number of failed tests}}{\text{Total number of tests}} \times 100\%$$

F_3 (amplitude) represents the amount by which the objectives are not met. F_3 is calculated in three steps.

Step 1. Calculation of excursion. An excursion (*Exc*) is the number of times an individual concentration is higher (or lower if the objective is to minimize) than the specified target.

$$Exc = \frac{\text{Failed test value}_i}{\text{Objective}_j} - 1$$

Step 2. Calculation of normalized sum of excursions. The normalized sum of excursions (*Nse*) is the collective amount by which individual tests are out of compliance. This is calculated by summing the excursions of individual tests from their objectives and dividing by the total number of tests (both those meeting objectives and those not meeting objectives).

$$Nse = \frac{\sum_{i=0}^{n} Exc_i}{\text{Total number of tests}}$$

Step 3. Calculation of F_3. Amplitude is calculated by an asymptotic function that scales the normalized sum of the excursions from objectives to yield a range from 0 to 100

$$F_3 = \frac{Nse}{0.01Nse + 0.01}$$

The CCME WQI is then calculated as

$$\text{CCME WQI} = 100 - \frac{\left(\left(F_1\right)^2 + \left(F_2\right)^2 + \left(F_3\right)^2\right)^{1/2}}{1.73}$$

The CCME WQI values are then converted into rankings by using the index categorization given in Table 1.

Table 1

CCME WQI range and classification [23]

Range	Details
95–100	excellent water quality protected with a virtual absence of threat or impairment, conditions very close to the natural or pristine level
80–94	good water quality protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels
65–79	fair water quality usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels
45–64	marginal water quality frequently threatened or impaired; conditions often depart from natural or desirable levels
0–44	poor water quality almost always threatened or impaired; conditions usually depart from natural or desirable levels

Socio-cultural influences on utilisation and river water quality of the Nubui River were explored by the sequential exploratory mixed method which combines both qualitative and quantitative methods as shown in Fig. 2.

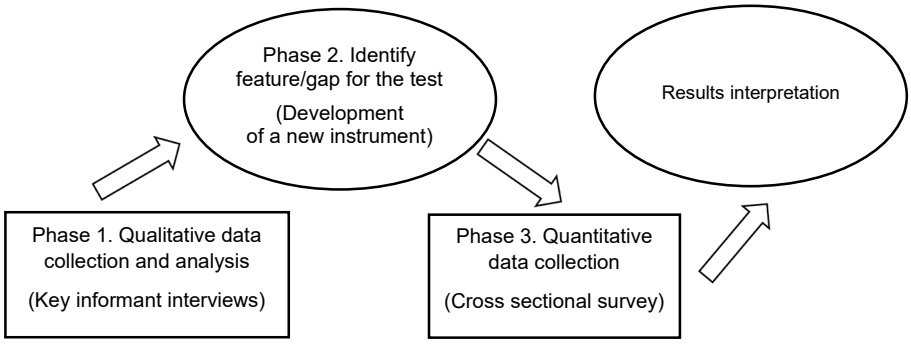

Fig. 2. Flow diagram of research design

This started with a qualitative phase where key informant interviews were conducted among 10 community leaders; responses were analysed using a thematic approach and the data was organized into themes.

Qualitative phase. Target participants. Ten key stakeholders comprising community leaders/household heads and custodians of the cultural history of the community, who live within the five Fodome communities (Helu, Woe, Hloma, Amele and Ahor), and depend on the Nubui River as their primary source of water were purposively selected. However, all community leaders who qualified to be included in the study but were not available due to ill health or otherwise were excluded from the study.

Data analysis. In-depth interviews were transcribed and analysed using a thematic analytical approach and discussed. Based on the findings and emerging themes of the qualitative study, a structured questionnaire was built using a five-point Likert scale is used to facilitate the judgment elicitation.

Quantitative phase. The objective of the quantitative study is the public perception of aesthetic quality and socio-cultural influences of utilisation; the justification for this research approach is to obtain quantifiable data useful for the generalization of findings. It also helps in eliminating or minimizing the subjectivity of judgment [24, 25]. To assess public perception of the aesthetic quality of water, a five-point Likert scale was adapted from Hu et al. [17], Water users were asked to select linguistic variables including "very poor", "poor", "fair", "good", and "excellent" to describe the taste, colour, and odour of water. The adapted instruments were modified to suit the objectives of the study and a test of reliability and validity analysis was done following pretesting in the study community.

Sampling strategy. The sampling strategy for the descriptive cross-sectional survey was a multistage random sampling technique. All five communities were considered different strata and respondents were randomly picked from each community with a sample size of 336.

Inclusion criteria. For the quantitative study, all male/female community members above 18 years of sound mind and were not in any ill health were included in the study. However, all male/female members of the study community who qualified to be selected for the study but were ill, not available during the time of data collection nor gave their consent for participation, were excluded from the study.

Quantitative data analysis. 338 questionnaires were used for the final analysis of the quantitative data. Data entry, cleaning, validation, and analysis were done using STATA® version 14. Both descriptive (frequencies with percentages and means with standard deviations) and inferential (bivariate and multivariate) statistical methods were applied to analyse the data results based on the objectives of the project. Frequency tables were used to describe the bio-demographic characteristics of the participants.

3. RESULTS AND DISCUSSIONS

3.1. PHYSICOCHEMICAL PARAMETERS AND BACTERIAL CONTENTS OF WATER SAMPLES FROM THE NUBUI RIVER

Water quality is reflected by the physical, chemical, and biological conditions depending on the intended use; however, when the water systems do not meet the standard quality criteria, it is referred to as being polluted and poses a threat to human health and ecological integrity [26]. Physical parameters include water turbidity, colour, and odour, which inform aesthetic quality, while chemical parameters including pH, oxygen concentrations (*DO*), hardness, total dissolved solids (*TDS*), alkalinity and concentration of heavy metals [27] also contribute to the overall quality of water, especially for drinking purposes. Water quality parameters falling short of the threshold, upon being compared to WHO drinking water quality standards, is largely attributed to anthropogenic activities and inputs.

Figure 3 shows the aesthetic quality of the Nubui River regarding colour throughout the year and recorded values between 0-500 Pt-Co, which corroborated with the field observation pictures, in both the wet and dry seasons. It is evident that in July following heavy rains, the colour of the Nubui River was poor, recording values between 103 and 500 Pt-Co; poor coloration was also recorded in August, September and October following rainfall events, hence weather patterns were a major contributor to the aesthetic quality of surface water. Figure 4 shows the turbidity of the Nubui River recorded throughout the sampling season.

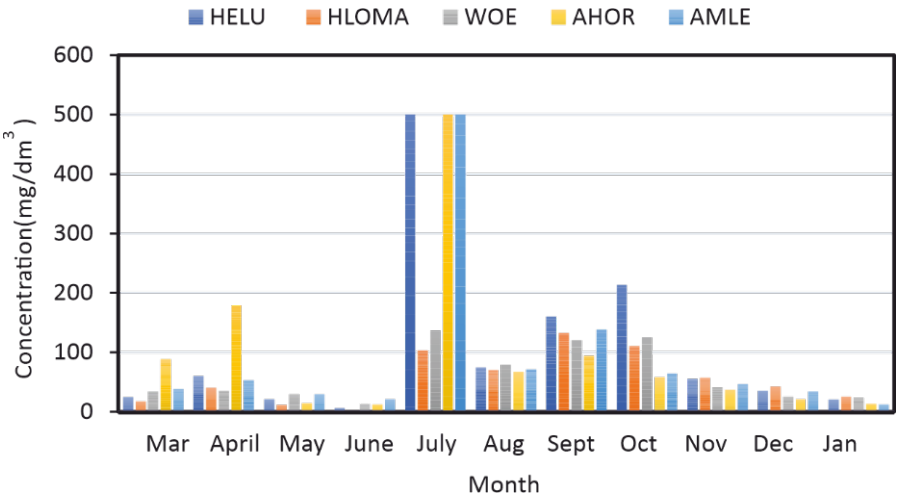

Fig. 3. Aesthetic quality (colour) in sampling locations

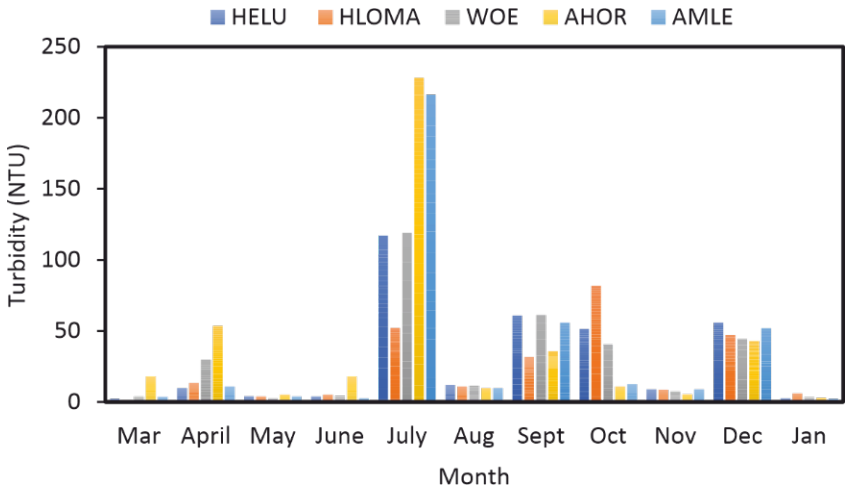

Fig. 4. Aesthetic quality (turbidity) throughout the sampling season

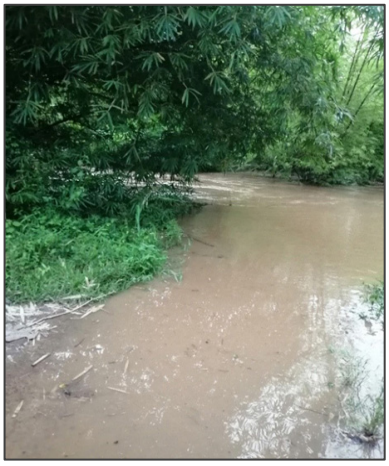

Fig. 5. Poor aesthetic quality in a wet season

Fig. 6. Poor aesthetic quality in a dry season

The turbidity is observed to be high throughout the sampling site and in all sampling seasons, high above the WHO drinking water guideline of 1 NTU, corroborating with the poor aesthetic quality recorded during field observations captured in Figs. 5 and 6. Water that lacks transparency or appears cloudy is known as turbid due to the presence of colloidal and suspended objects like clay, slits, finely divided organic and inorganic particles, plankton, and other tiny animals. Turbidity values increased, with increased surface runoff and erosion from adjacent riparian zones of water courses.

Colour of water is an aesthetic parameter that indicates quality; as seen in Figs. 5 and 6, the colour of the water source appears to be compromised, with evident variations

between the wet and dry seasons. These figures confirm the findings from the measured aesthetic parameters.

3.2. WATER QUALITY INDICES

Table 2 summarizes the average concentration of parameters used in water quality indices calculation over the sampling period.

Table 2

Results of physicochemical analysis of water (average values) over the sampling period

Month	pH	*EC* [µS/cm]	*TDS* [mg/dm^3]	TURB [NTU]	NO_3^--N [mg/dm^3]	PO_4^{3-}-P [mg/dm^3]	*DO* [mg/dm^3]	*E. coli* [cfu/cm^3]	*Salmonella* [cfu/cm^3]
St.	7.5	250	1000	1	11	0.29	7.5	0	0
March	6.714	32.6	21	5.654	0.82	0.026	5.154	337.34	20.2
April	6.262	33.2	21.8	23.334	0.34	0.042	2.146	252.5	0
May	6.212	34.6	22.8	3.76	0.28	0.162	4.008	216.44	0
June	6.182	29.2	19	6.676	0.74	0.076	4.752	449.45	151.5
July	6.224	90.6	59	146.4	0.32	0.084	6.886	308.46	414.1
Aug	6.47	45.2	29.6	10.6	1.62	0.092	5.756	308.46	414.1
Sept	6.746	48	31.2	48.88	0.54	0.054	7.346	0	0
Oct	5.542	41.4	25.4	39.24	2.36	0.282	6.842	0	0
Nov	5.688	27.2	17.6	7.642	0.066	0.033333	3.554	538.56	218.28
Dec	7.768	40.2	26.4	48.22	0.26	0.028	4.804	40.4	60.6
Jan	6.432	40.6	26.6	3.308	1.12	0.048	5.386	0	0

St. (standard) – drinking water.

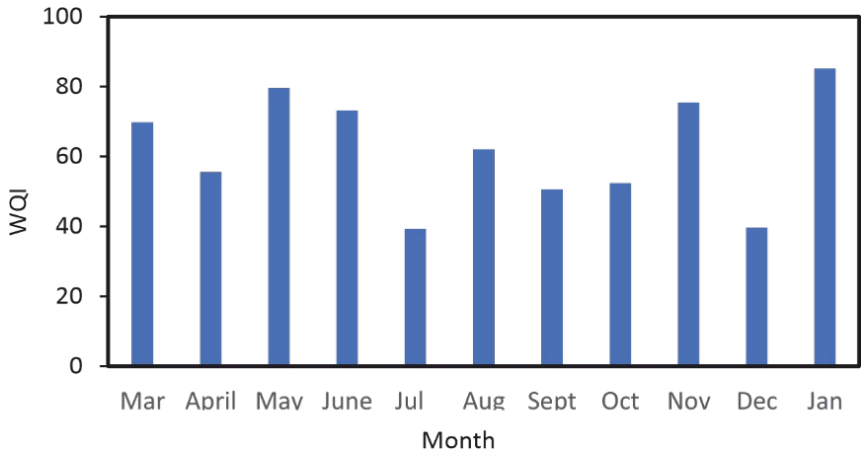

Fig. 7. Water quality indices of the Nubui River

Figure 7 presents CCME WQI throughout the sampling season, estimated with the average concentration of physico-chemical and microbial parameters summarized in Table 2. The WQI of the Nubui River indicates that March recorded water quality indices of 69.77, which is within the fair category of the CCME indices. April had a marginal water quality with an index value of 55.52; and dropped to fair in May. However, in June, July, August, September, and October, the Nubui River had fair, poor and marginal quality, which were the rainy parts of the year. In December it had poor water quality with a value of 39.70 and became good quality for the first time in January with an index of 85.12.

Approximately 18.18% of the 11-month water samples collected had poor quality with WQI within the range of 0–44; implying that the Nubui River is compromised, with local circumstances frequently deviating from ideal or natural thresholds [23]. Water samples collected in December, when there were pockets of rain at the beginning of the month and the peak rainy season of July recorded compromised quality. And 36.36% of water samples had marginal quality with WQI of 45–59, these were the months of April, July, August, September, and October with water quality being frequently threatened or impaired. These conditions often depart from natural or desirable levels and apparently, these were peak rainy months of the year and that influenced the quality of water. Also, within in March May and November, the Nubui River was of fair quality with WQI falling within 60–79; in these months water quality is usually protected but occasionally threatened or impaired. These conditions sometimes depart from natural or desirable levels, and it is only the month of January that had good quality indices with a value of 85.12.

Water quality indices change according to the seasons or weather patterns within the sampling seasons of the year and as mentioned earlier, it was not very distinct. During the dry months of November to January, water quality improved from poor to good. This result contrasts with data given by Hasan et al. [28], who attributed the worst water quality to the low flow of river water in winter. The reason given for more improved quality conditions in the post-monsoon (dry) season might be the rainfall in the monsoon which had a high flow of the river flushing out contaminants.

Overall, the quality of the Nubui River is not protected and there are obvious threats. The quality is either fair, marginal or poor, making it unfit for drinking; these conditions are far from clean through most parts of the year and this is because, throughout the sampling season, the Nubui River never recorded excellent WQI value.

3.3. MICROBIAL CONTAMINATION

The chat represented in Fig. 8 shows the microbial quality, between March 2022 to January 2023. The chat was represented by various averages (converted into log) with each microbe in the months. The figure revealed that July (5.32674538) and August

(5.32674538) had relatively the highest prevalence of aerobic plate count, following suit, by March with an aerobic plate count of 4.58795778.

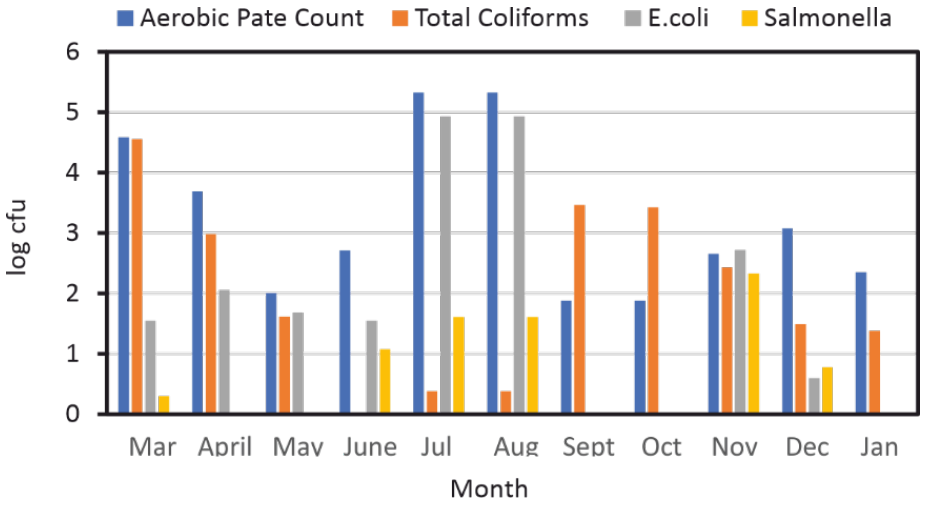

Fig. 8. Microbial quality of the Nubui River throughout the sampling period

Microbial contamination characterised by the presence of *Escherichia coli* in the Nubui River water is indicative of faecal contamination; this is the only member of the total coli form group of bacteria that is found in the intestines of mainly mammals including humans. Open defecation by humans, wastes from leaching animal manure, improperly treated septic and sewage discharge, stormwater runoff or domestic animals are the main contamination routes. During and following rainfall, bacteria and harmful microorganisms from these sources may be washed into surface water sources and contaminate.

3.4. SOCIO-DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS IN THE QUALITATIVE STUDY

Table 3 presents the socio-demographic characteristic of participants. One person had tertiary education, six participants had completed Senior High School (SHS), one person completed Junior High School (JHS) and one completed Primary school, while one had no formal education. Majority of the participants were Christians. Sixty percent of the participants were farmers and above the age of 60 years, indicative of the inclusion criteria which was targeted at community leaders and people who would were old enough to give historical information about the Nubui River and its socio-cultural significance to the community.

Table 3

Socio-demographic characteristics of qualitative participants

Characteristics	Frequency ($N = 10$)	Percentage
Age		
40–49	2	20
50–59	2	20
60–69	1	10
70–79	2	20
80–89	2	20
90–99	1	10
Education		
No formal education	1	10
Primary	1	10
JHS	1	10
SHS	6	60
Tertiary education	1	10
Religion		
Christian	5	50
Traditional	5	50
Occupation		
Farmer	6	60
Seamstress	1	10
Civil engineer	1	10
Unemployed	2	20

3.5. THEMATIC ANALYSIS OF QUALITATIVE FINDINGS

Table 4 shows the themes stemming from qualitative interviews conducted among the respondents. It presents the major and sub-themes from the thematic analysis. Following the transcription of the interviews, five major themes were identified through the qualitative analyses. They are presented in the table and twelve sub-themes were further identified. These include available sources of water, preferred sources of water for different uses, perception of quality, historical perspectives to use, identity, sense of ownership, socio-cultural influences and management approach adopted.

Findings from the field observation and qualitative study, summarized in Fig. 8 indicate that the Nubui River is the main source of water for most community members which is an unimproved source of water, with one borehole sunk in each sub-community. However, when most of the boreholes developed faults, the only improved source of water became inaccessible. Yahaya et al. [29] reiterated that the failure of improved sources of water including boreholes led to water accessibility issues. Another option for drinking water is the 500 cm^3 sachet water which can only be afforded by a few members of the community because of socio-economic challenges.

Table 4

Thematic analysis of qualitative interviews on socio-cultural influences and water quality

Theme	Details	Code
Sources of water supply	unimproved sources of supply improved sources of supply	surface water borehole stream rainwater sachet water
Perceptions on water quality	water quality	self-cleansing chemical input population increases other anthropogenic activities
Utilisation	aesthetic influence/appeal socio-economic issues folklore	taste odour colour – seasonal influences limited alternate options
Socio-cultural influences	culture, history, folklore	identity and ownership utilization and acceptance local rules and enforcement
Local management strategies	taboos, beliefs, norms	cleansing rituals sanctions and enforcements stakeholder engagement

3.5.1. SOURCES OF WATER SUPPLY

Kwakye-Nuako et al. [30] claimed that sachet water as a potential threat to the transmission of enteric pathogenic protozoan, may not even qualify as a safe source of drinking water. The sustainability of borehole water schemes is also a concern, with community participation being a key factor in their maintenance [31]. Therefore, the Nubui River is a crucial water source for many Fodome communities, but it is an unimproved source, and this can have significant health implications, as water-borne diseases are prevalent in communities with a limited supply of clean water.

3.5.2. PERCEPTIONS OF WATER QUALITY AND MOTIVATION FOR UTILISATION

The recurrent perception is that the Nubui River is self-cleaning, leaf litter purifies the water and therefore still good for drinking. This is potentially stemming from social influence and conformity where social pressure on individuals and their desire to conform to societal expectations can lead them to adopt the perceptions embedded in traditions, rumours, and culture shrouded in myths. These cultural norms have an impact on people's conduct, opinions about their surroundings and resources, and judgments and decisions [32].

The perception of the quality of the Nubui in comparison with other sources such as sachet water or treated water was reiterated about cultural norms and historical practices; this played a key role in preferences or water choices. In people's opinion, the

surface water source is very clean, without odour, safe for drinking and self-purifying as indicated by this participant.

It happened some time ago, some people from Amele got sick of Cholera; they washed clothes in the river, however, no one got sick because as the River flowed, the leaves in it killed that pathogen in the water (male, 82 years, Helu).

I would not pretend that sachet water, we are told is the best form of drinking water. But trust me, when we were not drinking treated water, people were living longer – our mothers, our fathers' grandmothers; they lived longer 90 years or 100 years. They never drank any treated water; they never even boiled water to store in anything; Nubui water was not even filtered before drinking. You could fetch this Nubui River and drink straightaway because they observed all these cultural norms, purification rites, laundry prohibitions, and no defecation (male, 58 years, Amele).

The preference and utilization of the Nubui River for drinking purposes in comparison with other sources was also strongly influenced by aesthetic appeal such as colour, odour, taste, and turbidity are basic parameters acceptable to consumers for drinking. This was also confirmed by Wasonga et al. [20], where respondents preferred a particular source of water because "it was sweet to drink" and also emphasized by Doria et al. [33], that perceived quality is strongly influenced by the flavour of the water. These aesthetic characteristics can significantly impact its acceptability and people tend to prefer water that is odorless or has a fresh and clean scent, hence quality and utilized for various purposes.

Therefore, respondents affirmed that their perception of aesthetic characteristics of water influences acceptance for drinking purposes regardless of the source of water. This assertion was confirmed by a respondent in this study who stated that,

Sachet water would have been better for drinking because it looks clear in appearance, though I did not personally witness the production to predict the quality. However, Nubui tastes better than sachet water because there is no salt and it is cool (female, 64 years, Tormegbe).

Though limited alternate sources of water also contributed to utilization as mentioned by a respondent from Amele who said: *it has a pleasant taste, you can feel it when you drink from Nubui. But we are also attached to it because that is the only water we have.* There is some level of attachment to these water sources from this response. The respondent confirmed that the Nubui tasted good, sweet and without salt compared to other sources available. Unlike the only borehole water in the community, the Nubui River water was reported to be odourless, feels cool and sweet and informed utilization for drinking purposes. Another respondent said: *Our ancestors depended on Nubui, it is cool and sweet and so my household and myself would depend on it, for various purposes* (male, 58 years, Amele). *When you drink from the Nubui, you would not like to take a sachet water again, in fact, Nubui feels cool like I took it from the fridge and lathers well with soap. It is very sweet, that is why we like it* (female, 72 years, Tormegbe).

Let me tell you, my son bought me sachet water (filtered water) from Accra, and for about two years now the water is still untouched in my room. I have never drunk any other water except the Nubui River. People in this village do not like any other water source apart from Nubui. If you see someone fetching pipe-borne water, that means he or she is closer to it and perhaps feeling reluctant to walk to fetch water at the riverside. One major thing about Nubui is that, aside from its pleasant taste it naturally feels cool (male, 82 years, Helu).

Another respondent also confirmed this by saying that people in this rural community do not like any other water source apart from Nubui and said *the only reason why people may fetch the borehole is because they were feeling reluctant to walk to the River.*

However, some participants had concerns about the influence of the weather and seasons on aesthetic and chemical quality even though it is a preferred source; saying that *the color of the Nubui changes during the wet season, the water starts looking muddy/mirky and I also suspect agrochemical run-off from nearby rice farms into the river and therefore in those times, water from the Nubui is not fit for drinking, but I drink from the borehole instead, though I do not enjoy it* (female 47 years, Tormegbe).

Other respondents asserted that some community members still drink from Nubui regardless of aesthetic problems. This is confirmed by another respondent that the Nubui was the best and he had never liked any other water source apart from Nubui. This respondent then concluded that regardless of aesthetic quality he still prefers it, because it is the ideal water for drinking. Another respondent confirmed: *Myself and my household use the Nubui for everything, I am a Nubui person;* this comment asserts that local people may see the Nubui River as a part of their cultural identity as well.

Aesthetic appeal, distance and limited alternate options may not be enough for acceptance or reason for utilization, which was apparent. Others believed the urge to drink the water stemmed from the attachments originating from the name Nubui which means to be lost. They believed that anyone who drank the Nubui was captivated by the taste and would not enjoy other sources of water. This idea of captivation was mentioned in a folklore narrated by another respondent saying, c*oncerning Nubui, our grandfathers told us that it originated from Togo Danyi. They said that at the time when an old lady was cooking in her kitchen, suddenly water burst out from her earthenware fire chamber. The water gradually increases in volume and flow until it reaches here. Indeed, it was narrated that it originated from the earthenware fire-chamber of a woman in Danyi. The water tastes pleasant, so if you drink Nubui you would not like to depart from here; you will be captivated by the taste* (female, 47 years, Tormegbe).

3.5.3. MOTIVATION FOR UTILISATION AND SOCIO-CULTURAL INFLUENCES

In the study community, local management strategies were bound by taboos, cultural norms and beliefs where cleansing rituals are performed to “purify” water. Sanc-

tions are given once local management rules are flouted and punishments enforced accordingly. This was congruent to a study conducted by Garn et al. [34] that socio-cultural factors for surface water use were influenced by community attitudes, beliefs, and values; this has a strong effect on individual members of the community group's behaviour.

Socio-cultural influences play a role in utilisation particularly for drinking because respondents typically told stories or gave brief historical accounts of how they felt attached to the water source and that formed a core part of the identity of some respondents. With the knowledge that the relationship between people and their environment may be deeply rooted in culture [19], there were socio-cultural attachments or reasons identified as one of the main reasons why community members may prefer the Nubui River. These responses are confirmed by field observations that, regardless of apparent aesthetic problems, community members preferred the water source for diverse domestic activities, including drinking purposes. Respondents confirmed Nubui to be a source of water for lots of generations, and did not cause death. There were responses such as *whether the Nubui is good or bad, it is the only source of water drunk by our forefathers and they were healthy before giving birth to us, so it is good to drink and others asserted that* Nubui River is a source of water for lots of generations, did not cause death. Furthermore, different respondents alluded to the assertion that distance was one of the main factors making people go for alternate options of water such as the borehole asserting that it is the lazy ones who do not want to walk to the riverside.

3.5.4. SOCIO-CULTURAL INFLUENCES AND MANAGEMENT STRATEGIES

Understanding how different human populations perceive aesthetics, and exploring the cultural contexts may effectively translate into the willingness to utilize or protect resources. From the findings of this study, Riparian Zone Management and protection of the Nubui is shrouded in myths, cultural norms and taboos. These include the prohibition of washing in the Nubui with soap on Thursdays, not dumping corps into the river, not entering the Nubui with slippers/footwear etc. and flouting any of these rules according to respondents came with severe consequences in the form of fines, sickness and even death.

One respondent narrated: *When I was attending school, they said that soap does not come into contact with water, but there was a schoolboy who was not an indigene of Fodome, bathed in the Nubui River on Thursday. He nearly died as a result, but fortunately, the elders performed some rituals to save his life. So, what the river hated is having contact with soap on Thursdays* (male, 53 years, Hloma).

The socio-cultural oriented management strategy stated by a respondent: *When I was a child, it was prohibited to farm near the Nubui or go near the river on Thursdays because that is the River's market day, we must respect it because it is a deity.*

The chiefs/community leaders applied sanctions to ensure compliance with local rules and management strategies. However, a respondent mentioned that most people were not abiding by the rules lately and Nubui is no longer safe because it is difficult to stop either stop people from applying agrochemicals to their farms which are in proximity or within the riparian buffer zone. In effect, agricultural extension officers from the Ministry of Agriculture urged community members not to drink from the Nubui during farming season. Enforcement of rules is becoming more challenging, and the built environment is making it easier for the river to become contaminated from various domestic sources.

3.5.5. HISTORICAL PERSPECTIVES TO USE, IDENTITY AND SENSE OF OWNERSHIP

There were also historical perspectives influencing utilization, which invariably translated into identity and a sense of ownership of the Nubui River by the Fodome community. This was told in a story by a respondent in Helu saying: *During the days of our great grandfather, this place was not called Fodome. The actual name was Yorve, hence we are Yorve people. The name Yorve because our forefathers lived long; and it was hard for them to die – yormeyiyi vaewoe.*

According to historical accounts, the early settlers were part of the Fodome people migrating from Abutia. Starting their journey, from Notse they settled in Abutia; and from Abutia they settled on a hill, however climbing the hill up and down became too difficult for them. Then the hunters started looking for better places, so a hunter came and discovered the Nubui River. And the taste and its cool nature made him settle around the Nubui River. So, it is more of a tradition, a feeling of being attached to it from ancient times. So, when our grandfathers tasted the water, they noticed that the water feels so cool and pleasant, hence they decided to name it Nubui, meaning, drink and honour it. Meaning that if you drink the water, you must honour it, hence the need to have local rules to do so.

3.6. SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE PARTICIPANTS – CROSS-SECTIONAL SURVEY

From Table 5, a total sample of 338 participants were included in this study. The mean age and standard deviation of the participants was 41.7±15.1 years. Most of the participants were females 211 (62.6%). Most 151 (44.7%) of the participants had a junior high school education. Moreover, most of the participants, 139 (41.1%), were self-employed.

Table 5

Socio-demographic characteristics of the participants

Variable	Frequency ($N = 338$)	Percentage
Mean age (*SD*)	41.7 (15.1)	–
Age group		
<30	79	23.4
30–39	93	27.5
40–49	58	17.2
50+	108	31.9
Sex		
Female	211	62.6
Male	126	37.4
Educational level		
None	29	8.6
Primary	44	13.0
Junior High School	151	44.7
Senior High School	82	24.3
Tertiary/ NVTI	32	9.4
Occupation		
Unemployed	48	14.2
Civil servant	26	7.7
Self-employed	139	41.1
Farmer	125	37.0

3.6.1. ACCESS TO WATER AND UTILISATION

From Table 6, 247 (73.1%) of community members used the Nubui water for various purposes, with 291 (86.1%) drinking from the Nubui River, 315 (93.2%) utilising it for laundry and for cooking 295 (87.3%). Most of the participants also drank from the borehole (175 (51.8%)), used it for cooking (195 (57. 7%)) but did not use it for laundry 215 (63.6%). Moreover, most of the participants drank sachet water (203 (60.1%)). However, almost all of the participants did not use sachet water for laundry (329 (97.3%)) and cooking (327 (97.3%)).

Previous studies and field observations indicate that remote rural community members utilise water resources sometimes regardless of apparent aesthetic issues. Therefore, a key question is whether it is because of a lack of alternate sources or other reasons such as socio-cultural attachments. The Nubui River stands out as the main water source for the local community, serving various needs such as drinking, cooking, and laundry. The apparent preference for Nubui water for multiple domestic purposes suggests a complex interplay of convenience, perception, and cultural practices. Unlike a study in the Pacific islands where women specifically collected water for distinct purposes based on water quality standards, this previous research showed that mothers prioritized

fetching quality drinking water, even if it meant travelling further while using more easily accessible water for other domestic chores [35]. However, in this current study, participants continued to opt for the Nubui River water despite the availability of nearby boreholes, indicating a strong influence of cultural expectations and attachments.

Table 6

Comparative utilisation of available water sources

(Improved/unimproved)	Frequency (N = 338)	Percentage
Source of water		
Borehole	85	25.1
Nubui	247	73.1
Sachet water	1	0.3
Rain	5	1.5
Nubui for drinking		
No	47	13.9
Yes	291	86.1
Nubui for laundry		
No	23	6.8
Yes	315	93.2
Nubui for cooking		
No	43	12.7
Yes	295	87.3
Borehole for drinking		
No	163	48.2
Yes	175	51.8
Borehole for laundry		
No	215	63.6
Yes	123	36.4
Borehole for cooking		
No	143	42.3
Yes	195	57.7
Sachet water for drinking		
No	135	39.9
Yes	203	60.1
Sachet water for laundry		
No	329	97.3
Yes	9	2.7
Sachet water for cooking		
No	327	96.7
Yes	11	3.3

Comparative analysis with prior research in Ghana highlights differences in borehole usage for drinking, underscoring contextual variations in water source preferences [36].

Nevertheless, the concern here lies in the reliance on Nubui water, particularly for drinking, despite potential water-related health risks for the population. However, despite the prevalent use of the Nubui water, a significant portion of participants refrained from drinking it, expressing concerns about its safety, consistent with literature linking water safety perceptions to usage patterns [37]. Packaged water, such as pure water, emerged as a popular alternative, reflecting a global trend in packaged water consumption [38]. However, that has also been found to be contaminated with faecal matter because of poor quality control measures during production [31]. This necessitates addressing socio-demographic nuances in water quality perceptions and utilisation patterns [39].

3.6.2. PERCEPTION OF AESTHETIC QUALITY

A majority of participants (43.5%) found the taste of the Nubui River to be satisfactory (Table 7). Most of the participants agreed that the Nubui River has a good smell 181 (53.6%) and agreed that the clarity of the Nubui River is good 191 (56.5%). 191 (56.5%) of the participants also agreed that the Nubui River had good quality. However, over 48% (163) of the participants expressed concerns about its safety for drinking purposes, suggesting a divergence between aesthetic perceptions and health-related considerations. Most of the participants (238 (70.4%)) agreed they had a socio-cultural attachment to the Nubui River, and 52.9% (148) of the participants agreed that norms influenced the utilisation of the Nubui River. Overall, most participants (199 (58.9%)) rated the aesthetic quality of the Nubui River positively, highlighting the complex relationship between perception, culture, and practical considerations in water source selection.

Table 7

Perception of aesthetic quality

Variable	Frequency ($N = 338$)	Percentage
Taste of the Nubui River water		
Poor	18	18.1
Fair	61	43.5
Good	147	33.1
Excellent	112	5.3
Odour of the Nubui River		
Poor	38	11.2
Fair	35	10.4
Good	181	53.6
Excellent	84	24.8
Clarity of the Nubui River		
Poor	18	5.3
Fair	59	17.5
Good	191	56.5
Excellent	70	20.7

Table 7

Perception of aesthetic quality

Variable	Frequency ($N = 338$)	Percentage
Quality of the Nubui River		
Poor	11	3.2
Fair	58	17.2
Good	191	56.5
Excellent	78	23.1
How concerned are you about the safety of the Nubui River for drinking purposes?		
Very unconcerned	2	0.6
Not concerned	58	17.2
Neither concerned nor unconcerned	31	9.2
Concerned	163	48.2
Very concerned	84	24.8
How important do you think safety of the Nubui River for drinking purposes?		
Very unimportant	3	0.9
Not important	35	10.4
Neutral	55	16.3
Important	170	50.3
Very important	75	22.2
How sure are you about the safety of the Nubui River for drinking purposes?		
Very unsure	39	11.5
Unsure	59	17.5
Neither sure unsure	138	40.8
Sure	90	26.6
Very sure	12	3.6
How sure are you about the safety of the Nubui River for various purposes		
Very unsure	47	13.9
Unsure	49	14.5
Neither sure unsure	137	40.5
Sure	95	28.1
Very sure	10	3.0
Do you have any socio-cultural attachments to the Nubui River?		
No	100	29.6
Yes	238	70.4
What types of socio-cultural attachments influence utilization?		
Cultural values	68	24.2
Folklore stories on quality	8	2.9
History	56	20.0
Norms	148	52.9
Overall perception of aesthetic quality		
Low aesthetic quality	139	41.1
High/Good aesthetic quality	199	58.9

Access to clean water is important to ensure good public health. The SDG (sustainable development goals) targets recommend a "leave no one" approach, yet human activities continue to threaten the quality of drinking water sources. Consumer perception of quality is important in determining utilisation options as established by seminal studies. The high percentage of participants rating these sensory aspects as good or excellent suggests that the Nubui River is generally well-regarded in terms of sensory attributes. This positive perception of the Nubui water is deeply rooted in generational use, local perceptions, and traditional ecological knowledge [19]. Besides, evidence shows that consumers expect consistency and the moment there is a deviation from characteristics expected by them is a sign of low quality, a concept referred to as familiarity with specific water properties [33]. The enduring use of the Nubui River water over time has likely cemented its preference compared to other options available. However, laboratory analyses revealed poor aesthetic quality and water quality indices indicating fair to marginal quality, contradicting the positive perceptions. Such positive perceptions align with the findings of the study on the aesthetic quality of rivers [19]. However, the quality of water particularly for drinking cannot only be determined by its clarity, flavour or even taste. The location of the water to pollution sources like farmlands, animals like cattle wading in the water, availability and proximity of toilet facilities in the community would also influence the quality of water. These are important factors to consider due to exposure to open defecation and some other animals discharge disease-causing agents like *E. coli* [40].

Surprisingly, despite the high-rating quality given to Nubui water, there was a substantial level of concern regarding the safety of the Nubui River for drinking purposes. Almost half of the participants expressed concerns, indicating a potential issue that necessitates further investigation. This finding aligns with studies emphasizing the importance of water safety perceptions in shaping community attitudes towards water sources [41]. It implies the need for water quality management and communication strategies to address public concerns.

A significant proportion of participants reported socio-cultural attachments to the Nubui River, influenced by cultural values, folklore stories, history, and norms. These factors contribute to the multifaceted nature of socio-cultural attachments to water bodies, shaping river rights, utilization, and promoting harmonious relationships with rivers [42, 43]. This cultural affinity explains the high utilization of the Nubui water despite alternative options. It underscores the dynamic interplay between cultural values and societal norms in determining the practical utilization of the river and highlights the importance of understanding cultural water requirements in managing water resources for human consumption and well-being [44].

3.6.3. MOTIVATION FOR UTILISATION OF THE NUBUI RIVER

Table 8 shows that participants aged 50+ were 3.48 times more likely to drink Nubui water as compared to participants below 30 years of age (*cOR* = 3.48 (95% *CI:* 1.48–8.19);

$p = 0.004$) (*cOR* is crude odds ratio, *CI* – confidence interval). Tertiary/NVTI participants are 97% less likely to drink Nubui water compared to participants with no level of education (*cOR* = 0.03 (95% *CI:* 0.00–0.23), $p = 0.001$). More so, civil servants are 77% less likely to drink Nubui water (*cOR* = 0.23 (95% *CI:* 0.08–0.64), $p = 0.005$) and farmers are 3.39 times more likely to drink Nubui water compared to unemployed participants (*cOR* = 3.39 (95% *CI:* 1.28–8.98), $p = 0.014$). Participants who were concerned about the safety of the Nubui water for drinking purposes were 2.83 times more likely to drink it compared to participants who were not concerned about the safety of the Nubui water for drinking purposes (*cOR* = 2.83 (95% *CI:* 1.50–5.33), $p = 0.001$) whereas participants who are concerned about the importance of the safety of the Nubui water are 2.21 times more likely to drink the Nubui water compared to participants who were not concerned about the importance of the safety of the Nubui water (*cOR* = 2.21 (95% *CI:* 1.17–4.18), $p = 0.014$). Nonetheless, participants who stated having socio-cultural norms are 88% less likely to use the Nubui water for laundry as compared to participants with no socio-cultural norms (*cOR* = 0.12 (95% *CI:* 0.02–0.95), $p = 0.044$).

Participants aged 50+ are 3.66 times more likely to use the Nubui River water for cooking compared to participants below 30 years old (*cOR* = 3.66 (95% *CI:* 1.43–9.40), $p = 0.007$). Participants who went to tertiary institutions were 88% less likely to use the Nubui water for cooking compared to participants with no level of education (*cOR* = 0.12 (95% *CI:* 0.02–0.61), $p = 0.011$). Also, farmers are 3.97 times more likely to use the Nubui water for cooking compared to unemployed participants (*cOR* = 3.97 (95% *CI:* 1.30–12.13), $p = 0.016$). Participants who were concerned about the safety and how important it was safe for drinking purposes were 3.43 and 2.11 times more likely to use the Nubui water for cooking compared to participants who were not concerned about the safety of the Nubui water for drinking purposes (*cOR* = 3.43 (95% *CI:* 1.78–6.61), $p < 0.001$) and (*cOR* = 2.11 (95% *CI:* 1.09–4,09), $p = 0.026$).

Participants with an educational level below tertiary and farmers in the community were likely to use the Nubui water for drinking and cooking; this sociodemographic group constitute people who are aged over 50+ and a majority among the study population. Probably they are highly inclined to and are more culturally attached to the water source. Their cultural beliefs or consistent use of the Nubui water makes them perceive it as safer compared to the other options and as explained earlier, consumers expect consistency and once this is met aesthetically, it is likely to be accepted; thus, familiarity with specific water [15, 33] and consumers perceive it as safe for use. Cultural belief influenced utilisation, where those who choose to align with socio-cultural norms are less likely to use Nubui water for laundry works but more likely to drink and cook with it, because of historical attachments; this can explained by the finding that river culture has spiritual and cultural significance on human wellbeing [45], which is convergent with the qualitative findings of this study. In adjusting for the factors motivating the use of the Nubui River, socio-cultural beliefs and attachment and history of socio-cultural attachment were the main factors determining the Nubui River utilisation.

Table 8

Association between utilization options and Nubui River *cOR* (95% *CI)*, *p*-value

Variable	Drinking	Laundry	Cooking
Age			
<30	Ref.	Ref.	Ref.
30–39	2.14 (0.96–4.74) 0.061	1.19 (0.27–4.91) 0.813	1.56 (0.70–3.49) 0.276
40–49	2.31 (0.89–5.93) 0.082	1.49 (0.26–8.44) 0.650	1.85 (0.70–4.84) 0.210
50+	3.48 (1.48–8.19) 0.004	0.39 (0.12–1.24) 0.122	3.66 (1.43–9.40) 0.007
Sex			
Female	Ref.	Ref.	Ref.
Male	0.63 (0.34–1.18) 0.152	1.39 (0.56–3.49) 0.477	0.62 (0.32–1.18) 0.146
Educational level			
None	Ref.	Ref.	Ref.
JHS	0.35 (0.04–2.77) 0.319	0.66 (0.08–5.59) 0.706	0.58 (0.12–2.66) 0.488
Primary	1.54 (0.09–25.57) 0.765	–	1.01 (0.16–6.46) 0.990
SHS	0.19 (0.02–1.52) 0.117	0.14 (0.02–1.14) 0.066	0.60 (0.12–2.96) 0.531
Tertiary/ NVTI	0.03 (0.00–0.23) 0.001	–	0.12 (0.02–0.61) 0.011
Occupation			
Unemployed	Ref.	Ref.	Ref.
Civil servant	0.23 (0.08–0.64) 0.005	0.80 (0.12–5.12) 0.814	0.32 (0.11–0.96) 0.042
Self-employed	2.35 (0.97–5.72) 0.060	0.48 (0.13–1.71) 0.257	1.26 (0.51–3.11) 0.611
Farmer	3.39 (1.28–8.98) 0.014	8.27 (0.84–81.53) 0.070	3.97 (1.30–12.13) 0.016
How concerned are you about the safety of the Nubui River for drinking purposes?			
Unconcerned	Ref.	Ref.	Ref.
Concerned	2.83 (1.50–5.33) 0.001	1.20 (0.48–3.03) 0.694	3.43 (1.78–6.61) <0.001
How important do you think about the safety of the Nubui River for drinking purposes?			
Not important	Ref.	Ref.	Ref.
Important	2.21 (1.17–4.18) 0.014	1.16 (0.46–2.93) 0.746	2.11 (1.09–4,09) 0.026
How sure are you about the safety of the Nubui River for drinking purposes?			
Unsure	Ref.	Ref.	Ref.
Sure	0.85 (0.44–9.51) 0.635	2.24 (0.74–6.76) 0.152	1.57 (0.74–3.31) 0.239
How sure are you about the safety of the Nubui River for various purposes?			
Unsure	Ref.	Ref.	Ref.
Sure	0.85 (0.44–9.51) 0.635	2.24 (0.74–6.76) 0.152	1.57 (0.74–3.31) 0.239
Do you have any socio-cultural attachments to the Nubui River?			
No	Ref.	Ref.	Ref.
Yes	5.57 (2.90–3.58) <0.001	1.04 (0.41–2.62) 0.926	4.57 (2.35–8.87) <0.001
What types of socio-cultural attachments influence utilization?			
Cultural values	Ref.	Ref.	Ref.
Folklore stories on quality	–	0.10 (0.01–1.86) 0.124	0.09 (0.01–0.76) 0.027
History	0.14 (0.03–0.67) 0.014	0.40 (0.34–4.56) 0.463	0.12 (0.03–0.59) 0.008
Norms	0.17 (0.04–0.76) 0.020	0.12 (0.02–0.95) 0.044	0.18 (0.04–0.81) 0.025
Overall perception of aesthetic quality			
Low perception	Ref.	Ref.	Ref.
High perception	4.42 (2.28–8.52) <0.001	1.50 (0.57–3.97) 0.414	4.71 (2.39–9.26) <0.001

Ref. is reference category.

This indicates that there is evidence of confounding variables in the other motivational factors revealed at the unadjusted level. These findings are consistent with previous research on water quality perceptions and the influence of socio-cultural factors [46]. However, in other instances, people with a history of socio-cultural attachment were less likely to drink Nubui water over time because of human development through education and knowledge of public health. For example, a study in Appalachia found that water quality perceptions changed across geographic and socio-economic gradients, indicating the influence of location and human development on the perceptions [47].

Research by Nagata et al. [48] suggests that socio-cultural beliefs and attachments often play a crucial role in shaping individuals' water-related decisions. Similarly, research on river restorations has shown that aesthetic preferences are linked to the ecological quality of rivers, highlighting the interconnectedness of socio-cultural and environmental factors [49]. By comparing these findings with existing literature, it becomes evident that socio-cultural factors significantly influence water resource utilisation and management. This highlights the importance of incorporating socio-cultural considerations into water resource policies and management practices.

3.7. INTEGRATIVE DISCUSSION FROM LABORATORY FINDINGS, FIELD OBSERVATION, QUALITATIVE AND QUANTITATIVE RESULTS

Regardless, of the Nubui River being utilised for various domestic purposes including drinking, meanwhile, the water quality indices (Fig. 7) show that it is not safe. Water quality indices of this water are confirmed to be between poor to marginal and yet still utilised for drinking purposes. There are apparent aesthetic issues during wet seasons (Fig. 5), where field observation and laboratory findings confirmed aesthetic problems of the Nubui River during most times of the year and possible microbial contamination. Therefore, apart from drinking purposes, it may be utilised for other domestic, recreational and hygiene purposes which should not lead to even incidental ingestion.

Community members were attached to the water source because of socio-cultural influences, which were told in the form of historical stories, taboos and norms. This confirms what Wasonga et al. [20] mentioned about water resource use management being culturally influenced and water management. Even though participants had other options such as a borehole, they still travelled to fetch water from the Nubui River. These had cultural underpinnings where women and girl children who preferred to fetch from the borehole closer were branded as lazy, instead of travelling to the River. Though previous studies confirm the effects of longer travel time for fetching water affecting the girl child's education and putting women at risk, because of the cultural expectation of women being responsible for water management in the home.

However, an innovation abstraction process was observed, which is the use of motorized tricycles which only a few people within the population could afford.

3.8. CONCLUSIONS AND RECOMMENDATIONS

Field observations reveal utilisation of the Nubui River for drinking, domestic activities, laundry and recreation (swimming), meanwhile, it records low-quality indices in most parts of the year, influenced by erratic seasonal variations. There is very little scientific understanding of quality issues because there is an assumption that the Nubui River is self-cleaning regardless of anthropogenic inputs during qualitative interviews. Therefore, the key feature/gap identified for further investigation is the public perception of quality, what informed utilisation preferences among the population.

Socio-cultural factors influence the perception of quality, water resource utilisation and management. Taboos, beliefs, and norms influenced local management strategies; this alludes to the fact that fields of environmental science, statistics, laboratory science, and public health are heavily influenced by anthropological viewpoints.

The application of anthropological concepts to public health practice and research enhances understanding; this is important to policymakers and practitioners to conduct proper community engagement, to reduce any socio-cultural barriers, in various water protection interventions.

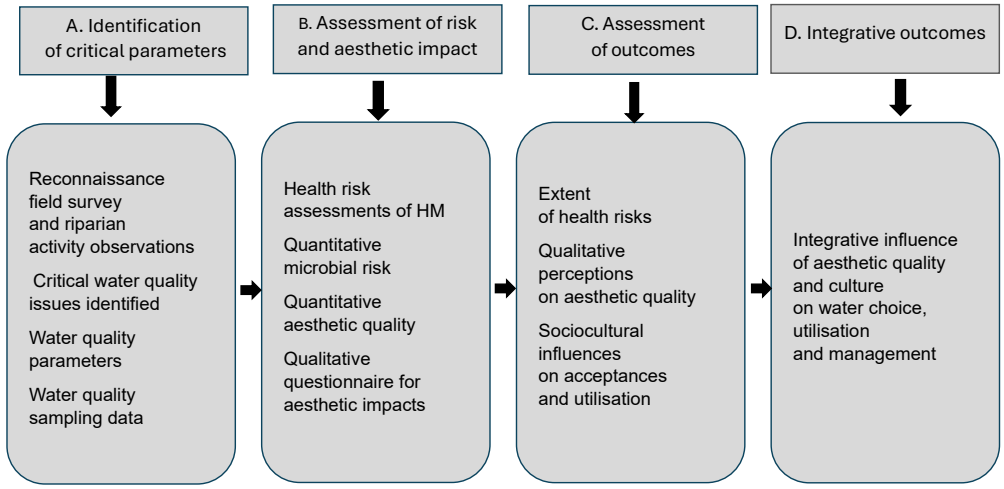

Fig. 9. Proposed framework of perception of consumer quality and drivers of utilisation (after [17])

There is a convergent association between qualitative and quantitative findings, underpinned by laboratory and field observation findings. This affirms that exploring human cultural contexts effectively translates into the willingness to utilise or protect water resources, hence an updated PFSE framework is developed and recommended for water quality assessments in rural and remote communities (RRCs).

Based on the preference of the Nubui River for drinking purposes, a point-of-use treatment device, like the sediment filter and nanofilter could be installed on the locally innovated abstraction devices. These treatment and filtering devices can also be installed on storage tanks built near the water source to improve the quality of the Nubui River abstracted for drinking purposes. This finding would be important to policymakers and practitioners to conduct proper community engagement, to reduce any socio-cultural barriers, in various water protection interventions.

STUDY PERMISSION AND ETHICAL ISSUES

Ethical approval for the study was given by the UNISA-CAES Health Research Ethics Committee and UHAS-Research Ethics Committee. The clearance certificates obtained from the UNISA had NHREC registration code (REC-170616-051) and UHAS Research Ethics Committee had the reference code UHAS-REC A.1[11]21-22.

The purpose and scope of the study were explained to community leaders for permission to be granted. Also, written informed consent was sought from participants before the interviews; a copy of the consent form containing detailed information about the study was given to participants.

ACKNOWLEDGEMENTS

The Department of Environmental Science at UNISA and the SASOL-NRF University Collaborative Research Grants (Grant No. 138626, Reference No. SASOL800405) are acknowledged as sources of support for the authors.

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