African Scientist Vol. 24, No. 1 March 31, 2023
Printed in Nigeria

1595-6881/2023 $80.00 + 0.00

https://africansciientistjournal.org

AFS2023008/24114

Assessment of Water, Sanitation and Hygiene (WaSH) Status and Water Qualities Using Physicochemical and Bacteriological Indices at Automobile Spare-Parts Markets in Benin City, Nigeria

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(Received March 16, 2023; Accepted in revised form March 23, 2023)

ABSTRACT: Global focus is currently on water, sanitation and hygiene (WaSH) due its public health and environmental significance. The aim of this study was to investigate the Water, Sanitation and Hygiene status of Uwelu and Evbareke spare parts markets in Benin City. Questionnaires were administered to evaluate the WaSH status of the markets. Physicochemical and bacteriological qualities of borehole water samples at the spare parts markets were investigated adopting standard analytical procedures and pour plate techniques respectively. Findings revealed that the pH values of Uwelu and Evbareke ranged from 5.28 - 5.29 and 4.78 - 5.11 respectively. The highest concentration of chloride was observed in Evbareke samples (49.70 mg/l) while that of nitrate and BOD_5 were 2.06mg/l in Evbareke and 0.88mg/l in Uwelu respectively. Comparing the value recorded in this study with WHO recommended standard which is 0.01-0.015mg/l, the mean value for Evbareke spare-parts market exceeded the recommended limit for lead at 0.02±0.025 mg/l. Total heterotrophic bacterial counts ranged from 3.1 - 4.4 × 10^2 cfu/ml and 3.1 - 2.9 × 10^2 cfu/ml (Evbareke). The total coliform counts in Uwelu and Evbareke spare parts markets ranged from 4 - 9 MPN/ml and 0 - 20 MPN/ml. The array of bacteria isolates was *Escherichia coli, Enterobacter* spp. *Klebsiella* sp. and *Staphylococcus* spp. Findings from this study suggest the urgent need to improve water safety, sanitation and hygiene policy of these studied popular automobile spare-parts markets in Benin City, Edo State.

Keywords: Evaluation, Hygiene, Sanitation, Spare-parts markets, Water

Introduction

Water sanitation and hygiene (WaSH) practice have become global issues and one of the United Nations Millennium Development Goals (MDGs) which is targeted at promoting environmental sustainability with the aim of reducing by half the proportion of people without sustainable access to safe drinking water and basic sanitation (Orimoloye *et al.,* 2015). The important role it plays in human survival cannot be over emphasized, especially in the sustenance of life and promotion of health (Orimoloye *et al.,* 2015). It is therefore not possible to separate the issue of water, sanitation and hygiene, as they have great impact on human health and wellbeing (Hutton *et al*., 2014). Improving global access to clean drinking water and safe sanitation is one of the least expensive and most effective means to improve public health and save lives (WHO, 2019).

The negative impacts of water scarcity and sanitation service extend beyond the equivocal consequence of disease outbreak. The collection of water, which in most developing clans is primarily the responsibility of women and children, represent an additional burden (Graham *et al.,* 2016) and the lack of water may prevent

people from practicing proper hygiene habit such as washing of hands before eating or after defecation, which obviously will lead to serious public health issues (Hutton *et al*., 2014).
The global burden of disease and mortality rates could be alleviated by about 9.1% and 6.3%, respectively, if rapid success is attained in facilitating access to water, sanitation, and hygiene facilities (Prüss *et al.,* 2008). Improving access to WASH services can improve health, prolong life expectancy, aid student learning, *gender equality*, and other important issues of international development (Kooy *et al.,* 2012*).* Clean water for ingestion and food preparation is necessary for human health (Vinod, 2019).
There is a need to create awareness through hygiene education programs and sensitization about good WASH practices to secure good public health in communities (David *et al.,* 2014). In Nigeria, it is expected that there is currently a dearth of data on the status of WASH; thus, it is increasingly becoming difficult to plan any meaningful WASH program to improve health and well-being (Wada *et al.,* 2022).
Water quality in several part of the world is adversely affected by urbanization (Linfang *et al.,* 2020). The drastic increase in population has led to increase in anthropogenic activities resulting to poorly or untreated sewage and polluted storm water, industrial effluent containing heavy metals and acid, agricultural discharge containing agrochemicals such as pesticides and fertilizers into surface water, thereby making water source unfit for use. (Sershen *et al.,* 2016).
According to UNICEF (2020), more than half of the 70% of water accessed by Nigerians are contaminated. This is an indication that majority of the water source utilized by most Nigerians are unfit for use (UNICEF, 2020).
The aim of this study was to assess the water, sanitation and hygiene (WaSH)) status and water qualities using physicochemical and bacteriological indices at automobile spare-parts markets in Benin City, Nigeria.

Materials and methods

Study area: This study was carried out in Uwelu and Evbareke spare parts market in Egor Local Government Area in Benin City, Edo State, situated at 06.36532 N, 005.60806 E and 06.37888 N, 005.58946 E respectively to access the water, sanitation and hygiene status of both markets using structured questionnaires. The studied locations are prominent commercial spare parts markets in Benin City, where all kinds of automobile parts as well as other products are on sale.

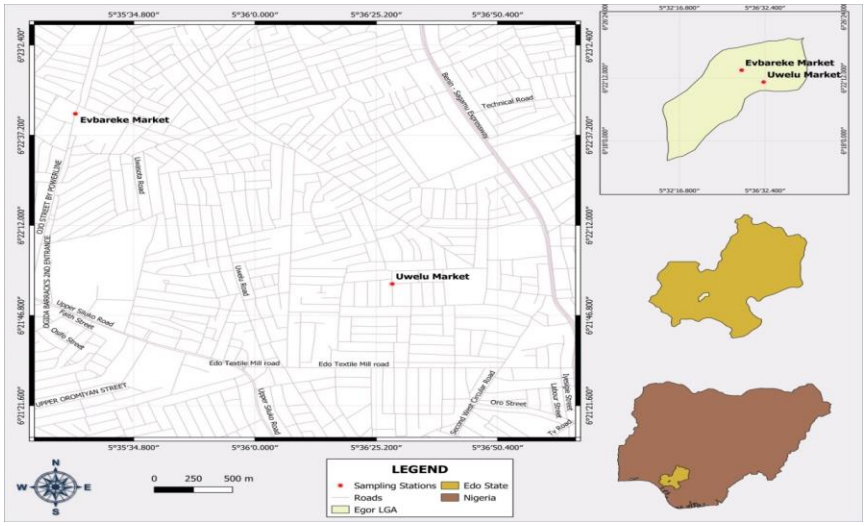

Fig 1: Map showing the sampling locations Benin City.

Plate 1A: Waste oil polluted location within Uwelu spare-parts market

Plate 1B: Dumpsite located within Evbareke spare-parts market

Plate 1C: A toilet facility at Uwelu market spare parts market

Plate 1D: A toilet facility in Evbareke market spare parts market.

Administration of questionnaire: A survey was carried out with the aid of questionnaire to get the opinions of the traders (respondents) on the status of water, sanitation and hygiene (WaSH) at the automobile spare-parts markets according to WHO (2016). A total of one hundred questionnaires were administered with fifty questionnaires at each market in course of this study.

Sample collection: Borehole water samples from the storage tanks were collected in sterile bottles containing pre-dosed sodium thiosulphate (1ml of 10% solution per bottle), transported to the laboratory in iced box at 5 ± 3 °C for physicochemical and microbiological analysis.

Analysis of physicochemical parameters of water samples:

pH: The pH of each sample was determined using a digital pH meter. The procedure involved standardizing the pH meter before and after each reading using freshly prepared neutral, acidic and basic pH buffers. The electrode probe was inserted into a glass beaker containing about 20 ml of the sample and the resultant value was read and recorded (Onyeonwu, 2000).

Analysis of chloride ion in water sample: Ten milliliters (10 ml) of water sample was measured into a 250 ml conical flask, and 3 drops of potassium chromate (K_2CrO_4) was added to the conical flask. 0.05 M of chloride standard stock was used as titrate, until there was a slight red precipitate appeared and then the titre value was recorded. The blank was treated with 9 ml of K_2CrO_4 indicator and 10 ml of 20 ppm Cl (Onyeonwu, 2000). The level of chloride was calculated using the formula:

$$\text{Cl (mg/l for water)} = \frac{\text{Molarity} \times \text{Titre} \times 1000 \times \text{Molecular weigh}}{\text{Aliquot taken}}$$

Analysis of nitrate in water: Aliquot of nitrate (10 ml) was measured into a beaker and 5 ml concentrated HCl and 2 g of granulated Zn/NaCl were added to form a mixture, it was then stirred at 30 rpm for 20 mins to convert nitrate into nitrite. The resultant was filtered through No. 41 Whatman filter paper to standard flask and diluted to 100 ml (Onyeonwu, 2000).

Biological Oxygen Demand (BOD_5): The water samples were aerated thoroughly, and water was added to the aerated sample. The sample was then seeded with a little diluted domestic wastewater (1-2 ml per liter). The

initial dissolve oxygen (DO) of the water was determination on suitable portion. A screw topped incubation bottle was filled to the brim with the remaining diluted water and incubated in a dark room for 5 days at 20 °C. The BOD_5 result was determined by the taking the differences dissolve oxygen (DO) level between Day 1 and Day 5 of the analysis (Onyeonwu, 2000).

$$BOD_5 = DO_1 - DO_5 = BOD$$

Heavy metal analysis: Selected heavy metals (iron, chromium and lead) concentrations were determined using the Atomic Absorption Spectrophotometer (AAS) (MODEL-SOLAAR 969 Unicam Series) (Onyeonwu, 2000).

Isolation and enumeration of heterotrophic bacterial isolates: Ten-fold serial dilution of the respective surface water samples was done up to 10^{-6} with sterile Peptone water utilized as diluent. The mean heterotrophic bacterial counts were determined using pour plate technique with nutrient agar utilized as general-purpose media respectively (Ogbuile *et al*., 1998; Harley and Prescott, 2002). The agar plates were swirled and allowed to solidify. The nutrient agar plates were incubated at 35 °C for 48 h. The resultant bacterial colony counts on the agar plates were enumerated manually and recorded (Cullimore, 2000; Collins *et al*., 2004; Cheesbrough, 2006).

Statistical analysis: All result was subjected to statistical analysis using Excel 2019 and SPSS 2019. The analyzed variables include; mean standard error and ANOVA.

Results and Discussion

The opinions of the respondents on socio-demography, water availability, sanitation and hygiene status of the studied automobile spare-parts markets (Uwelu and Evbareke) are presented in Figs 1 A-D and Tables 1-3. It was documented that the majority of respondent at Uwelu market were mostly women making up 38 (76 %) of the 50 respondents whereas only 12 (24 %) were men, and 31 (62 %) of the respondents were males and 19 (38 %) were females at Evbareke market. This assertion shows that automobile spare-parts business in these two markets is gender friendly as opposed to the general view that it is dominated by the male folk. The main source of water supply at the studied markets was borehole with overhead tanks as stated by the respondents (Table 1). It therefore implies that water is available at the markets and the people have access to water supply. The availability of water will obviously play favorable role in enhancing proper sanitation and hygiene in these studied markets. The responses on waste management in Uwelu and Evbareke markets clearly stated that the practice of waste sorting is not common at both markets, this will not only have negative effect on the market environment, but will also affect waste management practice such as reduction, reuse and recycling (Odiana and Olorunfemi, 2021). According to the responses obtained, open burning of waste was not usually carried out by traders in both spare parts markets, and wastes are generally collected by Wastes Management Board (Table 2). Waste burning increases the amount of greenhouse gases present in the atmosphere, as well as its negative impacts on human health (Rose *et al*., 2020). This finding is an indication of good waste management practice at the studied spare parts market, although there were few places where waste was inappropriately dumped within the markets.

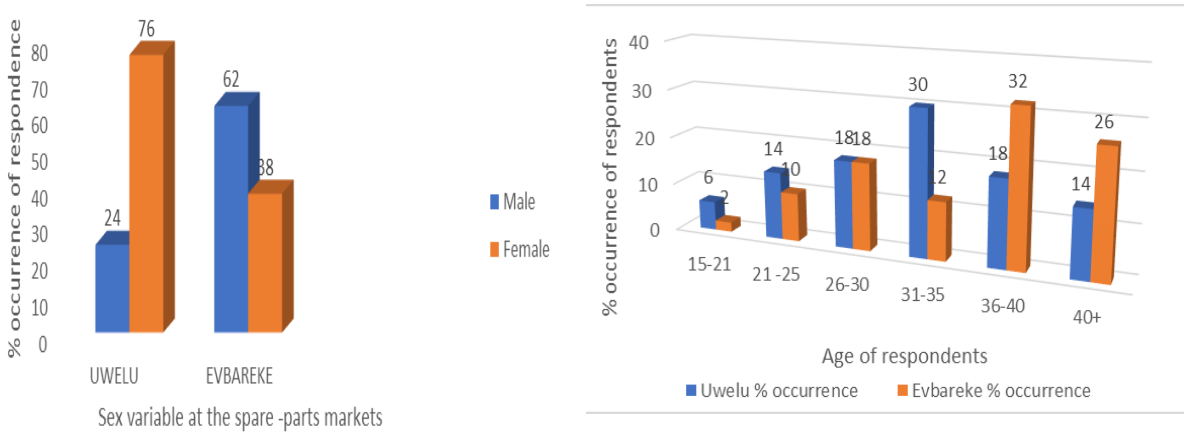

Figure 1 A-B: Socio-demography of traders at Uwelu and Evbareke spare parts markets in Benin City. 1**A** (Graph showing the sex variable at the spare-parts market), 1**B** (Graph showing the age of respondents at the spare-parts market),

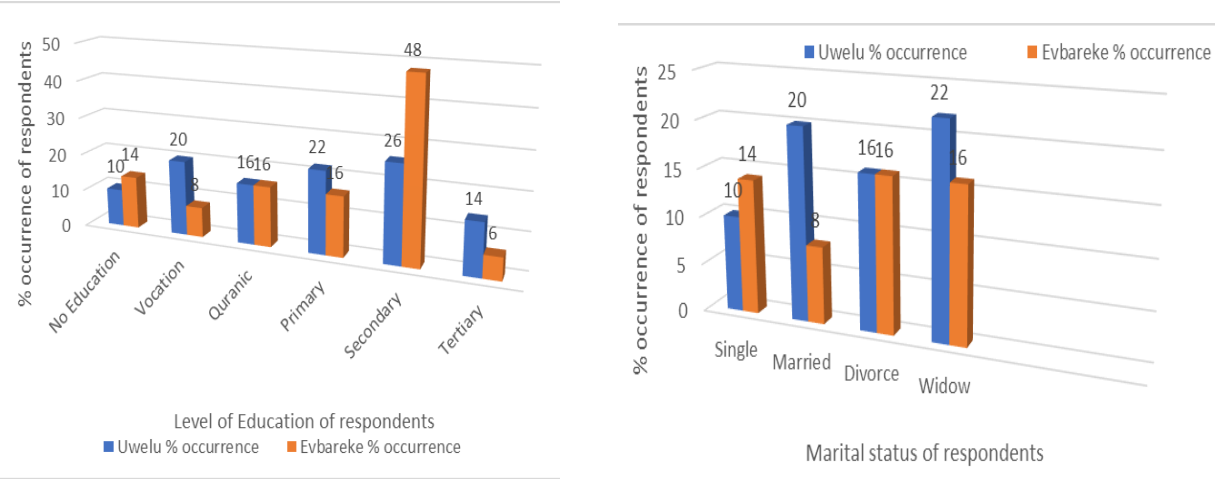

Figure 1 C-D: Socio-demography of traders at Uwelu and Evbareke spare parts markets in Benin City. 1**C** (Graph showing the level of education of respondents at the spare-parts market) and 1**D** (Graph showing the marital status of respondents at the spare-parts market)

Table 1: The water availability status of Uwelu and Evbareke markets according to respondents

Water	Variable	Uwelu		Evbareke	
		Occurrence frequency	% Occurrence	Occurrence frequency	% Occurrence
Water source	Piped	0	0	0	0
	Borehole	50	100	50	100
	Protected dud well	0	0	0	0
	Unprotected dug well	0	0	0	0
	Surface water	0	0	0	0
	Yes	49	98	50	100
Main water source at premise	500 meters off premises	1	2	0	0
	>500 meters off premises	0	0	0	0
	Strongly agreed	7	14	34	62
Water available on main source	Agreed	2	4	9	18
	Uncertain	1	2	1	2
	Disagreed	12	24	2	4
	Strongly disagreed	28	56	4	8

Reports also show that respondents (100 %) have access to toilet facilities at the markets (Table 2). The toilet type facility was described as flush-to-pit toilet system (Plates 5-6), however 34 (68 %) of respondents at Uwelu market indicated that the number of usable toilets were between 1-5, while 16 (32 %) stated between 5-10.

Table 2: The sanitation status of Uwelu and Evbareke markets according to Respondents

Sanitation	Variable	Uwelu		Evbareke	
		Occurrence frequency	% occurrence	Occurrence frequency	% occurrence
Are there staff employed to clean the toilets	Strongly agreed	32	64	48	96
	Agreed	18	36	2	4
	Uncertain	0	0	0	0
	Disagreed	0	0	0	0
Collected waste are openly burnt at the market	Strongly agreed	0	0	0	0
	Agreed	0	0	0	0
	Uncertain	0	0	0	0
	Disagreed	15	30	12	24
	Strongly disagreed	35	70	38	76

Sanitation	Variable	Uwelu		Evbareke	
		Occurrence frequency	% occurrence	Occurrence frequency	% occurrence
	Agreed	1	2	2	4
	Uncertain	0	0	4	8
	Disagreed	15	30	16	32
	Strongly disagreed	32	64	21	42
Waste are collected	Strongly agreed	40	80	37	84
by Edo State Waste	Agreed	5	10	4	8
Management	Uncertain	3	6	6	12
	Disagreed	2	4	3	6
	Strongly disagreed	0	0	0	0

Twenty-four (48 %) of the respondents, strongly agreed that male toilets were separated from females' while 12 (24 %) agreed to this, only 7 (14 %) disagreed stating that there is no restriction to the exact toilet that is accessed by both male and female (Table 3). The possibility for non-separation of toilet facility may infringe on the socio-gender right of the female traders of the markets.

Table 3: The hygiene status of Uwelu and Evbareke markets according to respondents

Hygiene	Variable	Uwelu		Evbareke	
		Occurrence frequency	% occurrence	Occurrence frequency	% occurrence
Number of usable	1-5	34	68	22	44
Toilet	5-10	16	32	28	56
	Flush to sewer	0	0	0	0
	Flush to pit	50	100	50	100
	Flush to open	0	0	0	0
Types of toilet	Uncovered latrine	0	0	0	0
	Pit latrine without slab	0	0	0	0
	Bucket	0	0	0	0
Separate toilets for	Strongly agreed	24	48	19	38
male and female	Agreed	12	24	8	16
	Uncertain	9	18	7	14
	Disagree	2	4	6	12
	Strongly disagree	5	10	10	20
Soap and water is	Yes	15	30	12	24
available at toilet	No	23	46	12	24
for hand wash	Sometimes	12	24	26	52

The results of the physicochemical quality of water samples from Uwelu and Evbareke spare-parts markets are presented in Table 4. The pH of samples from Uwelu and Evbarake spare-parts markets range from 5.28±0.05 - 5.29±0.05 mg/l and 4.78±0.05 - 5.11±0.05 mg/l respectively. The pH range value for both sample locations were well below WHO 6.5-8.50 recommended standard (Mike, 2013). The results obtained from this study are slightly similar to the results obtained from a research conducted by Ogbeifun *et al.* (2019) in Egor, where all two samples were acidic with mean value ranging from 5.07±0.00mg/l to 5.16±0.02mg/l. Although pH has no direct impact on human, however, all biochemical reactions are pH dependent (Ogbeifun *et al*., 2019). This therefore infers that the analyzed borehole water is slightly acidic for human and therefore not fit for consumption (WHO, 2014). Acidic water may occur naturally as a result of mixture of volcanic gases emanations in geothermal areas (Osei and Nkwame, 2004) or due to alteration in groundwater as stated by Umar and Absar, (2003) and may lead to serious health complications such as irritation in the eyes, skin and mucus membrane (Karunakaran, 2008). The concentration of chloride recorded in Uwelu had a mean value of 31.95±0.00mg/l, while Evbareke had 49.70±3.55mg/l as the highest value. The values obtained from samples were less than WHO recommended standard (250 mg/l) (WHO, 2014) and therefore within acceptable limit. High concentration of chloride in water had been observed to cause corrosion in metals (Wen *et al*., 2018).

Table 4: Results obtained from physicochemical analysis of Uwelu and Evbareke water samples

Parameter	UA	UB	EA	EB	WHO (2014)
pH	5.29±0.05[b]	5.28±0.05[b]	4.78±0.16[b]	5.11±0.17[b]	6.5-6.8
Chloride (mg/l)	31.95±0.00[c]	31.95±0.00[c]	42.60±3.55[d]	49.70±3.55[d]	250mg/l
Nitrate (mg/l)	0.42±0.20[a]	0.83±0.20[a]	2.06±0.45[a]	1.154±0.45[a]	50mg/l
BOD_5 (mg/l)	0.55±0.05[a]	0.88±0.05[a]	0.85±0.05[a]	0.23±0.05[a]	6mg/l
Iron (mg/l)	0.0±0.00[a]	0.1±0.005[a]	0.1±0.005[a]	0.0±0.00[a]	1mg/l
Lead (mg/l)	0.0±0.00[a]	0.01±0.005[a]	0.01±0.005[a]	0.02±0.025[a]	0.01mg/l
Chromium (mg/l)	0.05±0.025[a]	0.0±0.00[a]	0.06±0.02[a]	0.1±0.02[a]	0.05mg/l

Values are expressed as Mean ± Standard Error. Mean values with similar superscript are not significantly different from each other ($p<0.05$). Keys**:** UA: Uwelu A**,** UB: Uwelu B**,** EA: Evbareke A**,** EB: Evbareke B

The mean values recorded for nitrate in the sampled location were much lesser than the WHO standard 50mg/l. The concentrations range of nitrate was 0.42±0.20 - 0.83±0.20 mg/l (Uwelu spare-parts market), and 1.15±0.45 - 2.06±0.45 mg/l (Evbareke spare-parts market). According to Adeyemo *et al.* (2002), the natural concentration of nitrate in groundwater range from 0.1 to 10mg/l. This therefore infers that the concentration of nitrate in both spare parts markets did not exceed the natural concentration of nitrate. Drinking water which exceeds 50 mg/l of nitrate concentration can cause methamoglobinemia in infants (Fewtrell, 2004). The values for Biological Oxygen Demand (BOD_5) at Uwelu spare-parts market range from 0.55±0.05 to 0.88±0.05 and 0.85±0.05 to 0.23±0.05 for Evbareke spare-parts market. The values obtained in all samples were within the WHO recommended standard of 6 mg/l. The recorded concentrations of iron for Uwelu and Evbareke were found to be 0.1 ± 0.005 each, which is less than the WHO recommended standard of 1 mg/l. Comparing this value with the study carried out by Ogbeifun *et al.* (2019), which seems to imply that iron is constantly been deposited in the Benin City aquifer, signaling potential iron pollution with time if the source of the pollution remains unchecked. Lead is an environmentally persistent toxin that cannot be degraded by microbial activity (Rui *et al.*, 2015). On exposure to humans, it accumulates in bones and soft tissues, leading to chronic toxicity (Sihao *et al.*, 2011). Comparing the values recorded in this study with WHO recommended standard which is 0.01-0.015 mg/l, the mean value for Evbareke spare-parts market exceeded the recommended limit for lead at 0.02±0.025, while other samples were fairly within WHO recommended standard. The detected mean value of chromium in Evbareke spare-parts market had the highest concentration as compared to Uwelu spare-parts market. The recorded value for Evbareke spare-parts market range from 0.06±0.02 - 0.1±0.02 which exceeded WHO recommended standard, and thus not safe for human consumption. According Sreemoyee (2015), chromium has been found to cause chronic ulcers of the skin and irritative dermatitis as well as sinonasal cancer. The continuous entry of these heavy metals into the surrounding environment can result to serious ecotoxicological contamination (Imarhiagbe *et al.*, 2015).

Microbial contamination indicators are important water quality parameters since exposures to microbes from drinking water could imply severe public health problem through waterborne diseases (Gara *et al.*, 2018). Table 5 shows the total heterotrophic bacterial counts (THC) and total coliform counts from borehole water samples of the studied spare-parts markets. The Total Heterotrophic Counts (THC) values recorded in Uwelu were observed to range from 3.1- 4.4 ($\times 10^2$cfu/ml), while that of Evbareke range from 2.2 - 2.6 ($\times 10^2$ cfu/ml). Results of total coliform counts range from 4 -9 MPN/100ml and 0-20 MPN/100 ml for Uwelu and Evbareke spare-parts markets. The high population counts of bacteria in these water samples is an indication that the examined borehole water is a reservoir for the microbial contamination and diversity (Tirumalesh *et al.*, 2015, Imarhiagbe and Ikhajiagbe, 2018).

Table 5: Total heterotrophic bacteria count of Uwelu and Evbareke water sample

Sample	THB ($\times 10^2$ cfu/ml)	TCC (MPN/100ml)
Uwelu A	3.1	9
Uwelu B	4.4	4
Evbareke A	3.1	20
Evbareke B	2.9	0

Values are expressed as Mean ± Standard Error. Mean values with similar superscript are not significantly different from each other ($p<0.05$). Total heterotrophic bacterial counts (THB).

The bacteria isolated from this study were *Escherichia coli*, *Enterobacter* spp. *Klebsiella* sp. and *Staphylococcus* spp. which are of known public health significance (Harley and Prescott, 2002). Some of these organisms are

common environmental bacterial isolates, however, some of them such as *Enterobacter* and *Klebsiella* spp. are partly indicator coliform and their presence in water is an indirect reflection of human contamination of water sources (Akoma and Uhumwangho, 2016, Imarhiagbe and Onwudiwe, 2021). The growth and proliferation of microorganisms in these water samples can also be related to the state of storage tank.

Table 6: Cultural and morphological characteristics of bacteria isolates

Cultural characteristics	**1**	**2**	**3**	**4**
Colour	Cream	Golden yellow	Cream	Cream
Shape	Circular	Circular	Circular	Circular
Elevation	Convex	Convex	Convex	Convex
Margin	Entire	Entire	Entire	Entire
Size	Small	Small	Small	Small
Morphological characteristics				
KOH	+	-	-	-
Gram stain	-	+	+	-
Cell morphology	Rod	Cocci	Rod	Rod
Cell arrangement	Single	Clusters	Single	Chains
Biochemical characteristics				
Catalase	+	+	+	+
Indole	-	-	-	-
Oxidase	-	-	-	+
Citrate	+	+	+	+
Urease	+	+	-	-
H_2S production	-	-	-	-
Glucose	+	+	+	-
Lactose	+	+	-	-
Sucrose	+	+	+	-
Mannitol	+	+	+	+
Tentative Identity	*Escherichia coli*	*Staphylococcus* sp.	*Bacillus* sp.	*Enterobacter* sp

Conclusion:

The practice of water, sanitation and hygiene (WaSH) is of global interest and it is a United Nation's Sustainable Development Goal (SDG) target with focus on environmental sustainability. Findings from this study, suggest the urgent need to improve water safety, sanitation and hygiene policy in these studied automobile spare-parts markets in Benin City, Edo State. It is important to commend the appropriate authority for the provision of borehole and toilet facilities however; the quality of water must be put into consideration through provision of treatment plants so as to ensure its portability for human consumption and safety. It is also very important to note the need for consistent washing and maintenance of pre-existing water storage tanks to discourage the proliferation of microorganisms in water. Sensitization/awareness programs targeted to enhancing the knowledge, attitude and behaviour of traders towards the environment management should be carried out in both markets, as it will help reduce improper waste disposal as well as promoting other sanitation and hygiene practices.

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