THE NIGERIA ASSOCIATION OF HYDROLOGICAL SCIENCES (NAHS)

PROCEEDINGS OF THE

9th INTERNATIONAL CONFERENCE

EDO 2018

Theme: Water, Energy, Food and Environment (WEFE) Linkages

Edited by:
J.O Ehiorobo, A.I Agbonaye,
C.N Emeribe, O.C. Izinyon

New Senate Chambers, University of Benin
9th - 12th October, 2018

INFLUENCE OF BIOFILMS ON THE WATER QUALITY INDEX ASSESSMENT OF DISTRIBUTION WATER SYSTEMS OF SOME SELECTED HOSPITALITY INFLUENCE HOMES IN BENIN CITY, EDO STATE, NIGERIA.

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Abstract
Hospitality homes depend on bore holes for its water needs in developing countries. The research was aimed at assessing the water quality of hospitality homes from point of use faucets from selected well patronized hospitality homes situated in Benin City. Ninety samples were collected from faucets at three different points each of the six hospitality homes in sterile bottles. Physico-chemical parameters were determined using standard methods of American Public Health Association (APHA). The Total heterotrophic (THC) and total coliform (TCC) bacteria counts were carried out using required media and identified using molecular methods. The Water quality index (WQI) modelling approach was used in assessing the variation of the overall quality of the water sample at each specific location on monthly bases. Nineteen important physico-chemical parameters were used for this. Results obtained were reported to be below and above respectively of the permissible limits of World Health Organisation (WHO) and Federal Ministry of Environment (FMENV). The THC ranged from 3.7x 10^4 cfu/ml to 6.9x 10^4 cfu/ml Characterization of the bacterial isolates using gene sequence analysis showed the isolates to include the following; Providencia vermicola, Alcaligenes spp, Bacillus cereus, Pseudomonas aeruginosa, Staphylococcus aureus and Serratia liquefaciens. Results gotten were used to categorize the water quality based on its source. and then appropriate recommendations were made. There is need for use of water quality index modelling for hospitality industries to ensure proper water quality for its consumers and the public in general.

Keywords: Hospitality homes, water quality index, total heterotrophic count, *Pseudomonas aeruginosa*, *Alcaligenes* spp.

1.0 Introduction

The major source of water for hospitality homes and domestic use in Nigeria is ground water supply. Nigeria is one of the countries with polluted water. FAO (2005) recorded that only 60% of the total population had access to safe drinking water in 2002. Poor water quality brings about hostile circumstance so that water cannot be used for intended beneficial uses including bathing, recreation and as a source of raw water suppy. Poor water source is likely of biofilm formation. Biofilms consist of organized microbial communities of cells embedded in a gelatinous substance called EPS (Extra polymeric substance) which the organisms themselves produce. Biofilms are potential source of bacterial contamination of bulk water reaching the end user. Contamination of water distribution results from the microbial biofilm formed on the water pipe walls, followed by their detachment and their transport in the circulating liquid (Gouider *et al.*, 2009; September, *et al.*, 2007).

Water distributed in facilities such as hospitality homes are generally intended for several purposes like bathing and washing. A Hotel is an establishment which provides paid lodging and feeding on a short term basis. The goal of every successful Hotel business is to maintain a high level of customer satisfaction. Hotels are major water consumers because people tend to use more water in the hotels than in the homes (Charara *et al.*, 2011). Hotel size may not really matter in relation to water needs, rather its tourists' water usage patterns and factors such as seasons and climate are more important. The implication of this is that water management and facility maintenance which include water distribution piping systems

is the basic responsibility of hotels of all sizes (Kasim *et al.*, 2014).Decline in water quality may lead to recovery and subsequent growth of sublethally damaged bacteria due to system deficiencies such as cross connections, broken water mains and contamination during bulk storage & repairs (Camper et al., 1998). Furthermore these bacterial cells can attach and form biofilms on the surfaces of piping material from which cells may be released into the flow (Camper et al., 1998). The majority of bacteria in the drinking water system occur in biofilms rather than in water phase (Szewzyk et al., 2000). The leading cause of pollution in developing countries as Nigeria, is the disproportionate use of pesticides and/or fertilizers which seeps gradually into groundwater.

Developing countries are also facing a major lack of safe drinking water by the transmission of pathogenic microorganisms via fecal-oral route, which can cause enormous numbers of severe water related illness and is the major cause of deaths, especially in infants (Farkas, 2012). Increasing population's access to clean drinking water and sanitation facilities is one of the first priorities of local and global hospitalityhome authorities (Riley *et al,* 2011). Ground water quality assurance is facing new challenges, which comprise; biofouling issues, emergent waterborne pathogens, toxins releasing and occurrence of opportunistic water borne pathogens (João, 2010). Sensitive subpopulations such as young children, elderly persons or pregnant women are also vulnerable to infections caused by opportunistic pathogens (Reynolds *et al.*, 2008). Presence of opportunistic pathogen is often investigated, in addition to routine monitoring of drinking water for associated biofilms- as wide-occurring bacteria of concern in the continuously increasing category of hospitalised and ambulatory Immunocompromised persons (Glasmacher *et al.,* 2003). In drinking water systems, the high majority of bacteria, estimated at 95%, are located attached at the surfaces, while only 5% are found in water phase and detected by sampling as commonly used for quality control (Flemming et al, 2002).One of the advantages offered by drinking water biofilm organization to its members is represented by the enhanced resistance to disinfection residuals. The four hypothetical mechanisms of biofilm resistance involve slow antimicrobial penetration, deployment of adaptative stress responses, physiological heterogeneity in biofilm population and the presence of phenotypic variants or persister cells (Chambless et al, 2005).Experimental studies has emphasized on bacteria ability of colonization, survival and multiplication in water associated biofilms, followed by dispersion in water phase in a planktonic state (Banning et al.,2003). Water quality index (WQI) is one of the utmost current and easily logical tools to evaluate water quality for its appriopriateness for serveral use (Singh etal.,2013).

WQI is defined as, a rating reflecting the composite influence of different water quality parameters. Itis one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers (Ramakrishnaiah et al., 2009). According to World Health Organization (WHO, 2002) about 80% of all the diseases in human beings are caused by water.It therefore becomes important to frequently monitor groundwater quality and to find means to guard it. One way to monitor the quality of water is to constantly check the concentration of the associated parameters and cross correlates it against water quality standards. Other methods will involve the use of multi-variate statistics to monitor the variability of water quality parameters with time, location and distance and also the water quality index approach that helps to convert the overall quality of water samples into an index that can easily be managed and explained (Ilaboya et al., 2014) Portions of biofilm are frequently sloughed off pipe surfaces, resulting to microbes in the bulk water, suggesting biofilm cell detachment rather than growth of organisms in the water (Choi and Morgenroth, 2003). Hotels, Inns and Guest Houses, where people lodge for several days, may be a high risk environment due to the complex nature of the water distribution systems, and the possible sensitivities of most of its occupants.

As a result, a greater attention is being focused on hygienic risks associated with the use of the water distribution systems.

2.0 Materials and Method

2.1 Description of the Study Sites.

The study site, Benin City in Oredo Local Government Area, is situated 320 kilometers east of Lagos. Benin City has an estimated population of 1,147,188 people and lies geographically on Longitude 150 38' 0" East and Latitude 60 20' 0" North with a land mass of 19,794km^2 (NPC, 2006). Six Hospitality homes were carefully selected based on patronage.

Hospitality home A is located within Longitude 005°37.383'E and Latitude 06°18.506' N and was established in 2000, Hospitality home B is located within Longitude 005°37.457'E and Latitude 06°18.663' N and it was established in 2007. Hospitality home C located within Longitude 005°37.675° E and Latitude 06°.18.820° N and was established in 1996, Hospitality home D, located within Longitude 005°37.966'E and Latitude 06°18.202' N and was established in 2011. Hospitality home E located within Longitude 005°37.944'E and Latitude 06°18.715' N and was established in 1994 and Hospitality home F which is located within Longitude 005°36.983'E and Latitude 06°18.783' N and was established in 2008.

2.2 Collection of Samples.

Ninety water samples were collected from three sampling points (Room, Kitchen and Shower) from the faucets/point of use (ends of distribution Pipes (EDP)) from six hospitality homes studied between January, 2015 and November, 2015. Sterile swabs soaked in bacteriological (0.85%) saline were used to collect biofilm samples by vigorously rubbing the inner surface of the faucets, water samples were collected in sterilized 2 liter sampling bottles. All collected samples were then kept in the cooler box packed with ice and transported to the laboratory for analysis.

2.3 Bacteriological Analysis of Biofilm and Water Samples.

2.3.1 Determination of Total Heterotrophic bacterial counts

The swabbed stick containing biofilm was transferred to a sterile 5ml vial containing 1ml sterile (0.85%) saline. The suspension was homogenized by vortexing. Serial tenfold dilutions of each sample were prepared in test tubes using sterile bacteriological saline as the diluent. Triplicate spread plates were prepared using One hundred microlitres of three appropriate dilutions on Nutrient and EMB agar (Aneja 2003; Elhariry *et al.*, 2012). The methods of Cheesebrough (2001) were used for the determination of the total coliform and faecal coliform count. Each count was conducted in three stages.

2.3.2 Presumptive Stage; Fifty double strength MacConkey broth with an inverted Durham tube. 10ml of the sample was dispensed into 30ml test tubes containing 10ml of double strength medium with an inverted Durham tube. The procedure was carried out under aseptic conditions and the inoculated flasks and tubes were incubated at 30°C for 48 hours. This stage was repeated for the E. coli count but the flasks and tubes were incubated at 44 °C for 24hrs. Upon incubation, the flasks and tubes were examined for both acid and gas production. References were made on statistical tables (McCrady, 1918) to ascertain the total coliform and fecal coliform count in 100ml of the respective water samples.

2.3.3 Confirmatory Stage; One hundred microlitre (0.1µl) was transferred onto freshly prepared tubes containing 9ml of single strength MacConkey broth and inverted Durham tubes to detect gas production. The tubes were incubated at 30°C for total coliforms and 44 °C for 24hrs for *E. coli*.

2.3.4 Completed Stage; The positive confirmatory test tubes were used to inoculate EMB agar plates under aseptic conditions according to the method of Sharma (2009) colonies was observed and further biochemical tests such as Indole production, Citrate utilization, Coagulase and Urease production were done to further identify the various sub cultured colonies.

2.4. Identification and Molecular Characterization of Bacteria Isolates (Biofilm and Water Isolates).

Pure cultures of the heterotrophic bacteria isolates were identified and characterized on the basis of cultural, morphological and biochemical characteristics according to methods of Aneja (2003). Further

identification of the isolates was carried out using 16S ribosomal ribonucleic acid (16S rRNA) molecular assay (Olisaka and Ekhaise 2017).

2.5 Water Quality Assessment

Water quality index was calculated for each of the sample water collected from different locations (H1 to H6) for assessing the variation of the overall quality of the water sample at each specific location on monthly bases. The water quality index modeling was done by considering about nineteen (19) important physico-chemical parameters. The selected physico-chemical and microbiological parameters includes; pH, turbidity, total suspended solids (TSS), Electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), phosphate, nitrate, sulphate, total solids (TS), sodium, potassium, calcium, magnesium, iron, lead, cadmium, zinc, chloride, Total Heterotrophic count(THC), Total Coliform Count(TCC).

3.1 Results and Discussion

Table 1 shows the mean total viable heterotrophic bacterial biofilm count from the Room taps of six hospitality homes ranged from $2.13 \pm 0.30 \times 10^3$ cfu/cm^2 to $8.05 \pm 0.97 \times 10^3$ cfu/cm^2 in Hospitality home D and C respectively (Table 1). The mean total heterotrophic bacterial biofilm count from the Kitchen taps of six hospitality homes ranged from $2.44 \pm 0.24 \times 10^3$ cfu/cm^2 in hospitality home D to $8.38 \pm 1.96 \times 10^3$ cfu/cm^2 in hospitality home E (Table 1). The mean total heterotrophic bacterial biofilm count from the shower heads of six hospitality homes ranged from $2.59 \pm 0.18 \times 10^3$ cfu/cm^2 in hospitality home D to $10.27 \pm 1.96 \times 10^3$ cfu/cm^2 in hospitality home C (Table 1). There was no significant difference across all three points sampled.

Table 2 shows the mean total viable heterotrophic bacterial count from water samples of the taps of six hospitality homes. It ranged from $0.37 \pm 0.11 \times 10^2$ cfu/ml in the room of hospitality home C to $7.05 \pm 1.50 \times 10^2$ cfu/ml in the Kitchen of hospitality home D.

Table 3 shows the mean total coliform count from water samples of the taps of six hospitality homes. It ranged from 1.9 ± 0.37MPN/100ml in the room of hospitality home D to 10± 1.50MPN/100ml in the shower of hospitality home E.

Table 1: Mean heterotrophic bacterial biofilm count (cfu/cm^2) of three sampling points in all Hospitality homes

H/H	ROOM $\bar{X}$±S.E	KITCHEN $\bar{X}$±S.E	SHOWER $\bar{X}$±S.E	P-value	Significant level
Hospitality home A	3.356.0±2.308	3.159±0.231	2.909±0.286	0.46	P>0.05
Hospitality home B	3.509±0.346	3.323±0.491	2.950±0.255	0.57	P>0.05
Hospitality home C	8.050±0.972	8.046±0.606	10.273±1.962	0.39	P>0.05
Hospitality home D	2.132±0.304	2.449±0.246	2.590±0.186	0.42	P>0.05
Hospitality home E	7.546±1.662	8.380±1.969	8.226±1.704	0.94	P>0.05
Hospitality home F	4.783±0.730	4.196±1.264	5.023±0.973	0.83	P>0.05

Table 2: Mean heterotrophic bacterial count (cfu/ml) of water samples from three sampling points in all Hospitality homes

H/H	ROOM $\bar{X}$±S.E	KITCHEN $\bar{X}$±S.E	SHOWER $\bar{X}$±S.E	P-value	Significant level
Hospitality home A	1.22±0.13	0.96±0.21	2.12±0.29	0.003	P>0.01
Hospitality home B	0.72±0.13	0.94±0.19	1.18±0.18	0.184	P>0.05
Hospitality home C	5.75±1.49	7.05±1.50	5.77±1.46	0.781	P>0.05
Hospitality home D	0.37±0.11	0.63±0.21	0.61±0.10	0.424	P>0.05
Hospitality home E	4.02±1.67	5.92±1.30	6.74±1.54	0.868	P>0.05
Hospitality home F	2.0±1.07	10.20±1.67	9.00±1.73	0.153	P>0.05

Table 3: Mean total coliform count (MPN/100ml) of water samples from three sampling points in all Hospitality homes

H/H	ROOM $\bar{X}$±S.E	KITCHEN $\bar{X}$±S.E	SHOWER $\bar{X}$±S.E	P-value	Significant level
Hospitality home A	3.20±0.66	2.40±0.85	4.60±0.85	0.163	P>0.05
Hospitality home B	2.60±0.60	3.60±0.93	4.80±0.62	0.126	P>0.05
Hospitality home C	6.50±1.44	8.30±1.41	7.10±1.44	0.669	P>0.05
Hospitality home D	1.90±0.37	3.50±1.51	2.70±0.61	0.514	P>0.05
Hospitality home E	1.00±1.46	9.90±1.15	10.30±1.65	0.979	P>0.05
Hospitality home F	3.080±1.003	3.223±0.905	3.860±1.079	0.842	P>0.05

Table 4, shows the mean values of the ninety water samples collected from six Hospitality homes and used for the physicochemical parameters. The basic steps involved in the modeling of water quality index are discussed as follows:

3.2 Parameter Weightage Determination

For water quality index calculation, we first have to know the Weightage of each of the parameters identified. Parameters which have higher permissible limits are less harmful because they cannot significantly change the quality of the water sample even when they are present in high concentration. Weightage of tested parameters have an inverse relationship with its permissible limits. Therefore

$$W_n = \frac{1}{S_n} \tag{3.1}$$

W_n = Unit weight of the different parameters tested
S_n = Standard values of selected parameters (WHO Standard Permissible Limit)

Table 4; Mean values of the ninety water samples collected from six Hospitality homes(A to F) and used for the physicochemical parameters

Parameters	Hotel A	Hotel B	Hotel C	Hotel D	Hotel E	Hotel F	WHO LIMIT	FMENV LIMIT	SON LIMIT	Significant level
	$\bar{X}$±S.E	$\bar{X}$±S.E	$\bar{X}$±S.E	$\bar{X}$±S.E	$\bar{X}$±S.E	$\bar{X}$±S.E				
Temperature (°C)	21.45 ± 0.37	20.2 ± 0.36	20.9 ± 0.51	20.2 ± 0.29	20.6 ± 0.25	22.1 ± 0.27	NS	NS	Ambient	P<0.05
pH	6.128±0.090^{b}	7.084±0.153^{a}	5.381±0.117^{c}	6.276±0.054^{b}	5.380±0.113^{c}	5.711±0.182^{c}	8.2-8.8	6.5-8.5	6.5-8.5	**P<0.001****
Turbidity (NTU)	1.200±0.200^{b}	1.000±0.000^{b}	**6.000±0.577**^{a}	1.080±0.055^{b}	6.200±0.512^{a}	1.100±0.100^{b}	1.0	1.0	5	**P<0.001****
Total Suspended Solids(mg/l)	1.300±0.213^{b}	1.100±0.100^{b}	**6.100±0.737**^{a}	1.300±0.213^{b}	5.800±0.646^{a}	1.300±0.213^{b}	NS	>10	NS	**P<0.001****
Electrical conductivity(µs/cm)	17.067±1.018^{c}	23.500±0.785^{b}	31.763±1.690^{a}	14.807±0.305^{c}	30.695±1.475^{a}	30.119±2.809^{a}	NS	NS	NS	**P<0.001****
Total Dissolved Solids (mg/l)	9.409±0.559^{c}	9.729±0.411^{c}	25.260±1.179^{a}	7.837±0.251^{c}	25.386±1.050^{a}	17.056±1.676^{b}	NS	500	500	**P<0.001****
Dissolved Oxygen (mg/l)	7.223±0.158^{b}	7.270±0.182^{b}	5.488±0.091^{c}	7.075±0.149^{b}	5.473±0.062^{c}	7.681±0.132^{a}	NS	7.5	NS	**P<0.001****
Phosphorus (mg/l)	0.059±0.008^{b}	0.350±0.059^{a}	0.408±0.055^{a}	0.058±0.005^{b}	0.384±0.051^{a}	0.285±0.065^{a}	NS	>5	NS	**P<0.001****
Nitrate(mg/l)	0.898±0.051^{c}	1.057±0.061^{a}	1.440±0.100^{a}	0.777±0.019^{d}	1.499±0.090^{a}	1.038±0.097^{b}	50	10	50	**P<0.001****
Sulphate (mg/l)	0.930±0.141^{a}	0.485±0.087^{b}	0.979±0.096^{a}	1.070±0.068^{a}	0.944±0.095^{a}	1.021±0.077^{a}	NS	500	100	**P<0.01***
Total Solids (mg/l)	13.037±0.931^{c}	14.727±2.795^{c}	32.160±1.819^{a}	12.166±1.157^{d}	32.160±1.819^{a}	17.956±1.869^{b}	NS	NS	NS	**P<0.001****
Sodium (mg/l)	4.310±0.249^{a}	1.399±0.059^{b}	1.383±0.079^{b}	4.593±0.302^{a}	1.400±0.066^{b}	4.501±0.204^{a}	NS	200	200	**P<0.001****
Potassium (mg/l)	2.419±0.302^{a}	0.332±0.029^{c}	0.597±0.048^{c}	1.182±0.018^{b}	0.596±0.048^{c}	2.322±0.330^{a}	NS	NS	NS	**P<0.001****
Calcium (mg/l)	1.317±0.168^{a}	0.472±0.059^{d}	0.805±0.131^{c}	0.898±0.056^{b}	0.837±0.144^{c}	1.316±0.194^{a}	NS	NS	NS	**P<0.001****
Magnesium (mg/l)	1.123±0.167^{b}	0.756±0.083^{d}	0.826±0.100^{c}	0.499±0.035^{e}	0.865±0.122^{c}	1.176±0.163^{a}	NS	NS	0.20	P<0.01*
Iron (mg/l)	**0.506±0.039**^{e}	**0.583±0.048**^{b}	**0.676±0.032**^{a}	**0.464±0.022**^{c}	**0.667±0.041**^{a}	**0.533±0.065**^{c}	0.1	1.0	0.3	P<0.01*
Lead (mg/l)	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.01	0.05	0.01	P>0.05
Cadmium (mg/l)	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.001±0.000	0.003	0.01	0.003	P>0.0
Zinc (mg/l)	0.066±0.005	0.062±0.006	0.056±0.005	0.058±0.006	0.055±0.005	0.060±0.006	NS	5.0	3.0	P>
Chloride (mg/l)	87.000±11.576	78.500±9.833	108.000±8.103	77.000±8.537	108.50±8.411	87.000±11.576	NS	250	250	

3.3 Quality Rating or Sub Index of Selected Parameters

Rating scale was prepared for range of values of each parameter. The rating varies from 0 to 100 and is divided into five intervals. The rating $q_n = 0$ implies that the parameter present in water exceeds the standard maximum permissible limits and water is severely polluted. On the other hand $q_n = 100$ implies that the parameter present in water has the most desirable value. This scale is the modified version of rating scale given by Tiwari and Mishra (1985) and is calculated as follows:

$$q_n = \frac{100(V_n - V_{io})}{(S_n - V_{io})} \quad (3.2)$$

Where:

q_n = Quality rating or sub index

V_n = Laboratory test result for each parameter tested

S_n = Standard value of each parameter tested (WHO standard for drinking water)

V_{io} = ideal value of selected parameters tested (in pure water $V_{io} = 0$ for all parameters tested except pH and dissolved oxygen which is 7.0 and 14.6 respectively.

3.3.1 Water Quality Index Calculation

Essentially, a Water Quality Index (WQI) is a compilation of a number of parameters that can be used to determine the overall quality of water sample. The parameters chosen for the Water Quality Index (WQI) compilation are: pH, turbidity, total suspended solids (TSS), Electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), phosphate, nitrate, sulphate, total solids (TS), sodium, potassium, calcium, magnesium, iron, lead, cadmium, zinc, chloride. The numerical value is then multiplied by a weighting factor that is relative to the significance of the test to water quality. The sum of the resulting values is added together to arrive at an overall water quality index. It is basically a mathematical means of calculating a single value from multiple test results. The WQI result represents the level of water quality in a given location. The following steps were employed in computing the overall water quality.

The weightage unit (W_n) for all parameters tested were determined and summed up to obtain $\sum W_n$

The quality rating or sub-index for all parameters tested were determined and summed up to obtain $\sum q_n$

The index $W_n * q_n$ was calculated for each parameter tested and summed up to obtain $\sum W_n . q_n$

Finally, Water Quality Index (WQI) was computed for each location using the mass balance equation of the form:

$$(100) - \left(\frac{\sum W_n . q_n}{\sum W_n}\right) \quad (3.3)$$

To visualize the monthly variability of the computed water quality index for a specific location, pictorial representation using bar chart was done as presented in figures 4.1a-f

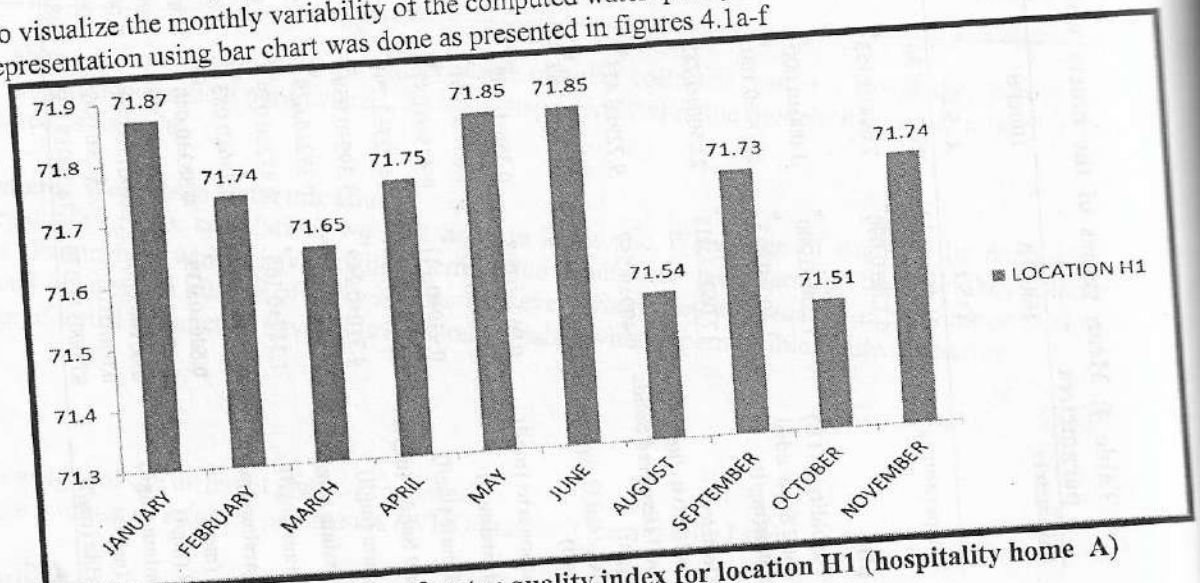

Figure 1.1a; Monthly variation of water quality index for location H1 (hospitality home A)

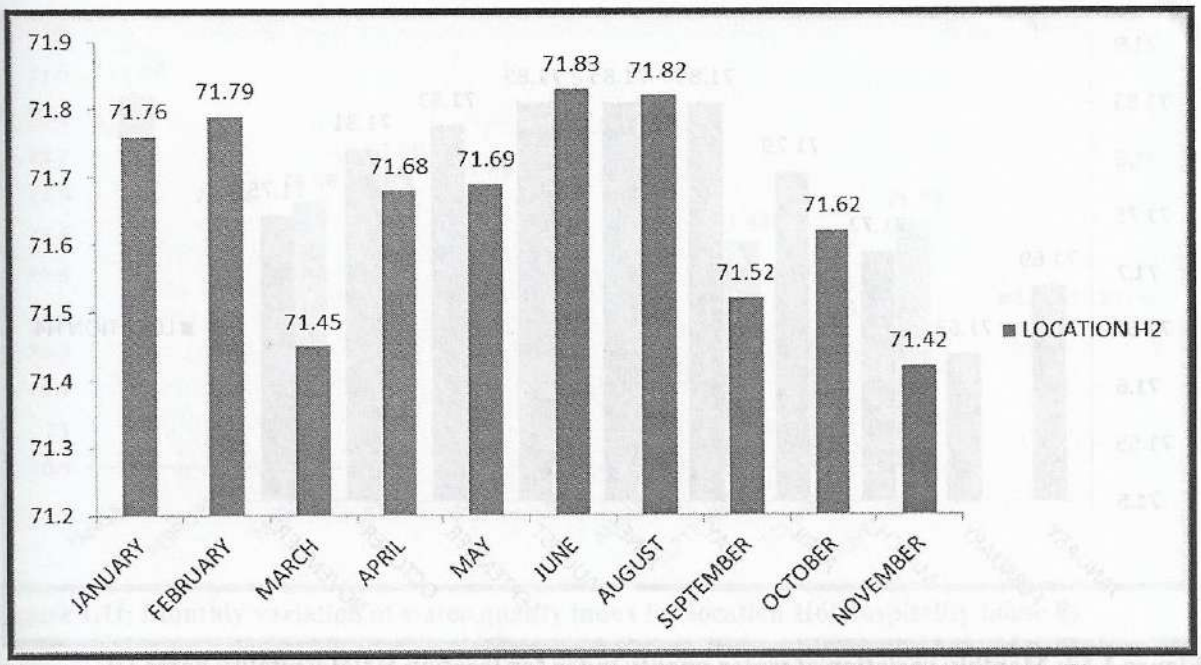

Figure 1.1b; Monthly variation of water quality index for location H2(Hospitality home B)

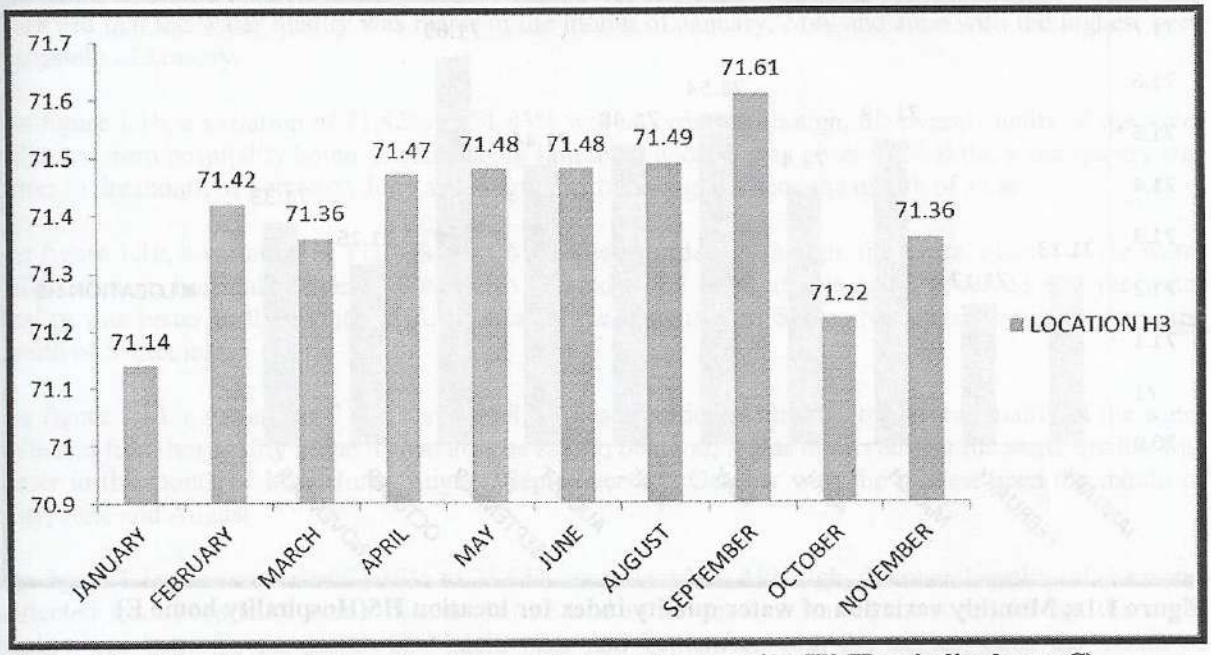

Figure 1.1c; Monthly variation of water quality index for location H3(Hospitality home C)

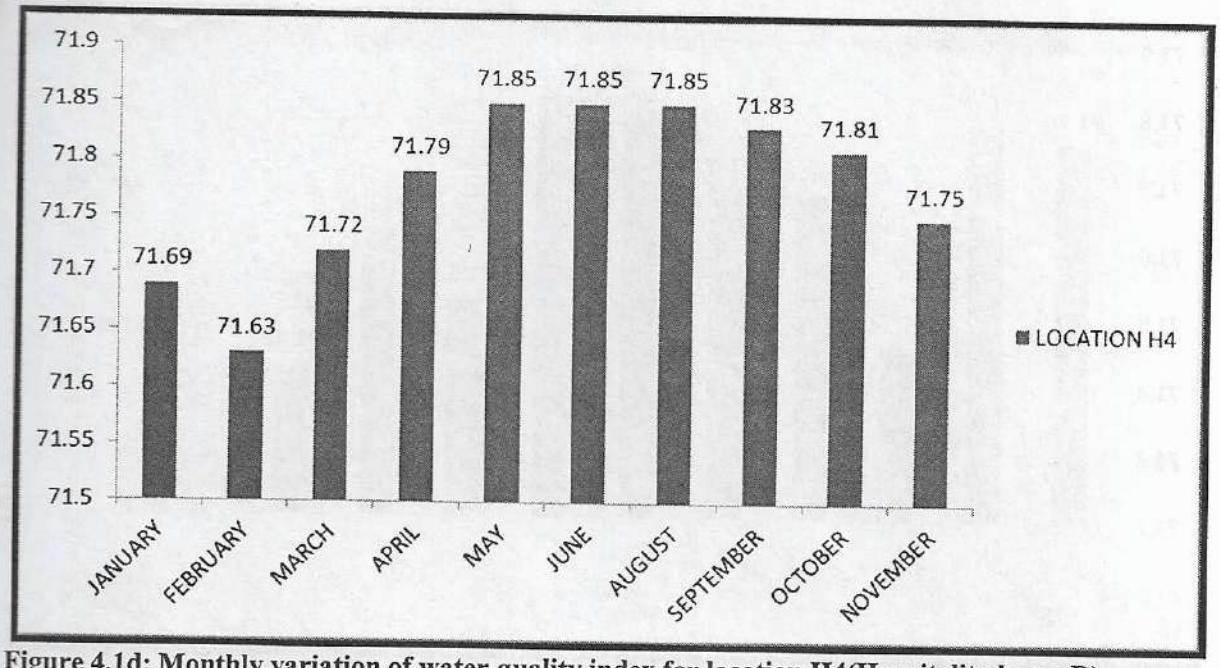

Figure 4.1d; Monthly variation of water quality index for location H4(Hospitality home D)

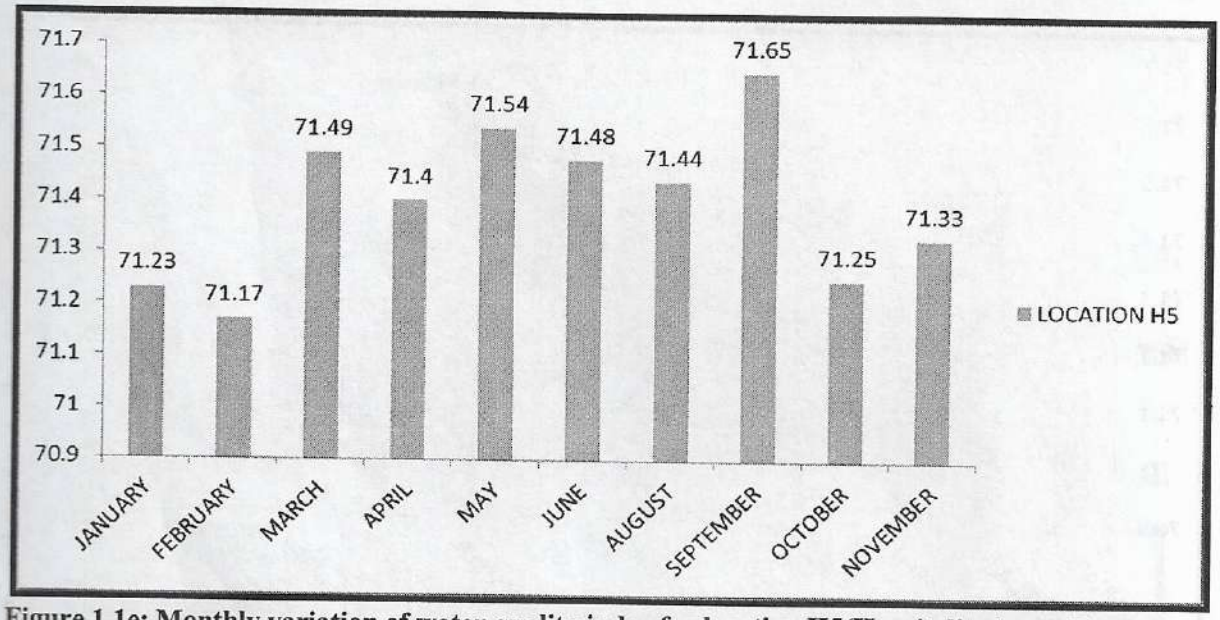

Figure 1.1e; Monthly variation of water quality index for location H5(Hospitality home E)

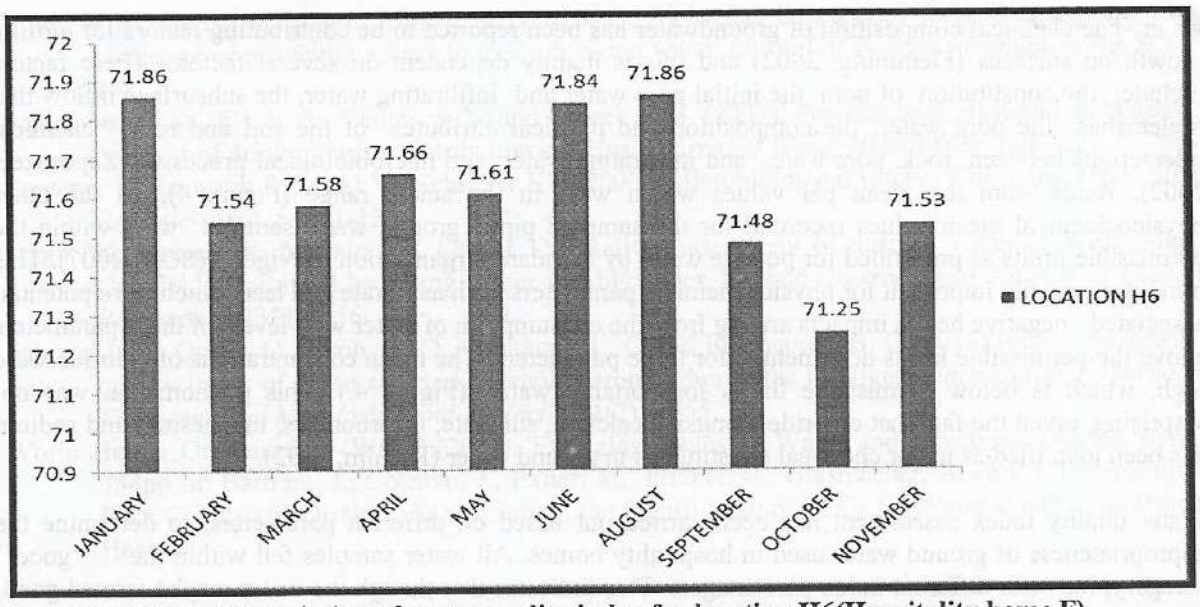

Figure 1.1f; Monthly variation of water quality index for location H6(Hospitality home F)

Result of figure 1.1a shows a variation in the computed water quality index from 71.51% to 71.87%. Although, the overal quality of the water collected from hospitality home A can be said to be good, it was observed that the water quality was better in the month of January, May and June with the highest been the month of January.

For figure 1.1b, a variation of 71.42% to 71.83% was recorded. Although, the overal quality of the water collected from hospitality home B can also be said to be good, it was observed that the water quality was better in the month of February, June and August with the highest been the month of June.

For figure 1.1c, a variation of 71.14% to 71.61% was recorded. Although, the overal quality of the water collected from hospitality home C can also be said to be good, it was again observed that the water quality was better in the month of April, May, June, August and September with the highest been the month of September.

For figure 1.1d, a variation of 71.63% to 71.85% was recorded. Although, the overal quality of the water collected from hospitality home D can also be said to be good, it was observed that the water quality was better in the month of May, June, August, September and October with the highest been the month of May, June and August

For figure 1.1e, a variation of 71.17% to 71.65% was recorded. Although, the overal quality of the water collected from hospitality home E can also be said to be good, it was again observed that the water quality was better in the month of March, May and September with the highest been the month of September.

For figure 1.1f, a variation of 71.25% to 71.86% was recorded. Although, the overal quality of the water collected from hospitality home E can also be said to be good, it was observed that the water quality was better in the month of January, June and August with the highest been the month of January and August.

4.0 Conclusion

Bacterial biofilm which are of public health importance is known to be associated with biofouling in hospitality homes. The presence of microbes in pipe-borne water, results in colonization of the distribution systems infrastructure and subsequent biofilm formation. These organisms may have tendency to get to consumers through the use of such contaminated water or food contaminated with such

water. The chemical composition of groundwater has been reported to be contributing factors for biofilm growth on surfaces (Flemming, 2002) and this is mainly dependent on several factors. These factors include; the constitution of both the initial pore water and infiltrating water, the subsurface inflow that replenishes the pore water; the composition and physical attributes of the soil and rock; chemical interactions between rock, pore water, and infiltrating water; and microbiological processes (Zaporozec, 2002). Aside from the mean pH values which were in the acidic range (Figure 4), all the other physicochemical mean values recorded for the sampled piped ground water samples were within the permissible limits as prescribed for potable water by Standard Organisation of Nigeria (SON, 2007). This trend is especially important for physicochemical parameters such as nitrate and lead which have potential associated negative health impacts arising from the consumption of water with levels of these parameters above the permissible limits documented for these parameters. The mean concentrations of chloride were high, which is below permissible limits for portable water, (Figure 4.). This phenomenon was not surprising, given the fact that chloride alongside calcium, sulphate, bicarbonates, magnesium and sodium has been identified as major chemical constituents in ground water (Romijn, 2002).

Water quality index assessment has been carried out based on different parameters, to determine the appropriateness of ground water used in hospitality homes. All water samples fell within the □ 'good'' category, but with different index percentages. This indicates that though the water maybe termed good, but might not be suitable for consumption, but may require continuous and steady treatment to be termed ''Excellent''.it could be seen from table 2 and table 3 that the count of biofilm greatly exceeds that of the water count, which shows that there might be a slough off of bacteria from the pipes of faucets to the end user. This may in turn affect the quality of the water in that particular location (Choi and Morgenroth, 2003). The highest water quality index was found in hospitality home A while the lowest was found in hospitality home C. The physicochemical parameters tell us that other parameters may be responsible for the high and low water quality index respectively. A principal component analysis is suggested to be carried out to know what parameters exactly are responsible for the different index ranges.). There is great need to understand the interfaces between the pipe–water points owing to its essential role in the management and is critical to managing and conserving the quality of potable water and its general advantage to the public. Unfriendly health concerns connected with the use of these commercial outfits may be stopped through precise information on probable health risks.

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