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Water Quality Assessment of Aminu Kano Hostel

Obaro Ajeke
Department of Civil Engineering, Faculty of Engineering, University of Benin, Edo State, Nigeria
Corresponding Author: ajekeobarorakpo@gmail.com

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Abstract

Water quality assessment is the overall process of evaluation of the physical, chemical, and biological nature of the water. Aminu Kano Hostel (Hall 3) is a student hostel in Ugbowo Campus, University of Benin, which suffers from water quality and water utility problems. This study will expose the problems facing the water supply of the hostel, thus serving as justification for maintenance and repairs in the hostel. The water distribution network of the hostel was drawn with AutoCAD. The coordinates of the nodes were determined using Google Maps. The length of the links was measured with a measuring tape where possible or estimated with Google Maps in other places. From this data and visual inspection, the water supply appurtenances were graded. Water samples were gotten from the source of water distribution and the blocks in the hostel. Laboratory tests for some important water quality parameters were carried out and the Canadian water quality index was calculated from the results. The average grading of the nodes and link was Fair. The average water quality index was 69.6426. Thus the water supply utility of the hostel is fairly sustainable and the water quality is fair. It is recommended that the water utility in the hostel be adequately maintained to have an adequate water quality and water utility in the hostel.

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1. Introduction

Water is a substance composed of oxygen and hydrogen with the molecular formula H_2O. It can exist in liquid, solid and gaseous states [1]. Every day, people depend on the health benefits that clean and safe water provides [2]. Water constitutes one of the basic human needs. It is one of the world's most valuable resources [3]. It is a basic necessity of life for both plants and animals [4]. Mankind cannot survive without water as even the human body is made up of about 70% water [5].

Water quality is becoming more of a problem in developing countries. Drinking water sources are under increasing threat from contamination, with far-reaching consequences for the health of individuals and the economic and social development of communities. Because of the critical importance of water to so many facets of human health, growth, and well-being, a water-related objective was included in the Millennium Development Goals (MDGs) Report 2012 [6].

Water is generally recognized as the most valuable natural resource in Nigeria; however, freshwater environments are directly threatened by human activity and are expected to be further impacted by climate change and anthropogenic activities [7]. The water resources of Nigeria are enormous and unevenly distributed among the various hydrological areas [8]. No community can function without access to potable water and sanitation, so it is critical to constantly consider solutions to issues with water supply and sanitation [World Health Organization [WHO], 9]. Based on the above, it is reasonable to conclude that water supply and distribution should be examined at all levels. The researcher is inspired to conduct a water utility assessment of Aminu Kano hostel to determine the extent to which water supply has impacted the residents of Nigerian university hostels.

This paper presents findings of a study on the performance of the water supply of Aminu Kano Hall compared to best practice targets and standards. Water quality tests were carried out to determine the potability and quality of the water in the hostel.

2. Methodology

2.1 Study Area

The project site is Hall 3 Hostel (Aminu Kano Hall), the University of Benin, situated at Ugbowo, Benin. The coordinates of the hostel as determined from Google Maps are 6.39745^{0}N, 5.62102^{0}E. The hostel is made up of 6 blocks: Block A, Block B, Block C, Block D, Block E, and Block F. Each block has a population of 320. The hostel is mixed gender; Block A and Block B are for female students while the remaining blocks are for male students.

Figure 1: Satellite view of Hall 3 Hostel from Google Maps

2.2 Survey of Water Utility of Hall 3

Materials Used: Measuring tape, Google maps, Sketchpad

Procedure:
By leveraging the view from the hostel flyover, the perimeter of the hostel will be observed and sketched. The shape, dimensions, and spacing of the blocks will be determined. Due to erosion, most sections of the underground water pipes are exposed and are visible. This condition of the pipes will be used to determine the path and location of most components of the water distribution.

A shutoff valve was observed at the beginning of the water distribution. This valve will be used to determine the direction of flow in the pipes. The pipes will be traced from the source to all tanks and taps on ground level.

With all this information, the water distribution system of Hall 3 will be sketched on a sketchpad. Starting from the source, the network will be surveyed again. This time, the conditions and physical properties of the pipes, pumps, and tanks will be measured and recorded. Any necessary corrections to the initial sketch will be made. The length of pipes and coordinates of junctions, tanks, and reservoirs will be determined from Google Maps and recorded.

AutoCAD will be used to produce an electronic version of the water network drawing on the sketchpad.

2.3 Collection of Water Samples

Water samples will be collected based on the type of analysis to be performed. Samples for the physical and chemical analysis will be taken from Hall 3. Six samples will be taken; one from each block except Block B, and one from the source of water distribution. Block B is exempted because it rarely has water. After collection, the samples will be taken to the laboratory for the tests.

2.4 Water Quality Tests

Several water quality tests were carried out on each water sample. The tests include turbidity, conductivity, total dissolved solids, pH, nitrate, phosphate and heavy metals test and microbiology analysis.

2.4.1 Turbidity test

The researcher carefully collected a water sample, avoiding sediment from the bottom. The turbidity tube was rinsed with the test water, and the sample was stirred vigorously to ensure homogeneity while minimizing air introduction. The researcher positioned their head 10 cm above the tube to observe the viewing disk as the water was poured slowly, preventing bubbles. If bubbles formed, pouring paused until they dissipated. Water was added gradually until the disk's pattern became difficult to see, at which point pouring stopped immediately. The water level was read directly from the markings on the tube and recorded as the turbidity in Nephelometric Turbidity Units (NTU).

2.4.2 Conductivity and Total dissolved solids

A conductivity meter (WTW Series Cond 730) was used to measure water samples. It was calibrated with 0.01M KCl solution. For each sample, 100ml was placed in a beaker, and the probe was inserted until the digital reading stabilized, recording conductivity or total dissolved solids.

2.4.3 Total hardness

Total hardness was measured by adding 50ml of the sample to a 250ml conical flask, followed by 2ml of buffer solution and 2 drops of Erichrome black T indicator. The mixture was titrated with 0.1M EDTA until a blue endpoint was reached. Total hardness as $CaCO_3$ (mg/L) was calculated using the formula:

$$\text{Total hardness} = (V \times A \times 1000) / (\text{ml sample}) \qquad (1)$$

where V = volume of EDTA used (ml) and A = amount of $CaCO_3$ equivalent to 1ml EDTA.

2.4.4. pH test

The pH of water samples was measured using a Hanna pH meter (Hi-1922 model). The meter was calibrated with buffer 7.0 and rinsed with distilled water. For each sample, 20ml was placed in a beaker (pre-rinsed with distilled water and a small amount of the sample), and the pH was measured following the same process.

2.4.5 Microbiology analysis

The filtration apparatus includes a hand vacuum pump, filtrate flask, sampling cup, graduated funnel, membrane support, sealing gaskets, and a glass sintered disc. The apparatus is assembled as required. To prepare Membrane Lauryl Sulfate Broth (MLSB), 7.6g of MLSB powder is dissolved in 100mL deionized water, ensuring the silica gel in the sachet is not green, indicating moisture. The silica gel is removed, and the powder is poured into water, gently heated to dissolve without boiling, transferred to clean 125mL bottles, and sterilized at 121°C for 10 minutes. After cooling, the bottles are stored in a cool, dark place, and excess MLSB is discarded once the pad is saturated.

Samples for coliform analysis must be incubated within 6 hours of collection. A sterile absorbent pad is placed in a petri dish and saturated with MLSB broth. A sterile membrane is placed on the glass support using sterilized forceps, and the water sample is filtered through the membrane using a hand vacuum pump. The membrane is then placed on the saturated pad, labeled, and incubated after a 1-hour resuscitation period to allow stressed coliforms to recover.

After incubation, yellow colonies on the membrane are counted within minutes to prevent color changes. Non-yellow colonies are ignored. If 100mL of the sample was filtered, the number of yellow colonies equals the faecal coliform count per 100mL, and the results are recorded accordingly.

2.4.6 Dissolved oxygen

In the lab, 2 ml of concentrated tetraoxosulphate (VI) acid was added to a fixed sample, dissolving a brown precipitate and producing a golden yellow color, indicating the liberation of iodine equivalent to the dissolved oxygen in the water. A 100 ml portion of the solution was mixed with 1-2 ml of starch indicator, turning it dark blue. This solution was titrated with sodium thiosulphate ($Na_2S_2O_3$) until it became colorless. The volume of titrant used corresponds to the dissolved oxygen (DO) concentration in mg/l. Winkler's solution A contains $MnSO_4$, while solution B consists of KOH and KI.

2.4.7 Biological oxygen demand

The water samples were incubated at 20°C for five days in an incubator in the laboratory. The sample was fixed using Winkler's A and B solution on day 5 [10].

BOD = DO1−DO5

Where DO1 = Dissolved oxygen at day one, DO5 = Dissolved oxygen at end of five days

2.4.8 Nitrate

A clean cuvette was filled with 10 mL of distilled water, wiped, and used to calibrate the colorimeter by pressing the "Zero" button. If the water sample contained particles, it was filtered. Another cuvette was filled with 10 mL of the filtered sample, and a NitraVer 5 powder pillow was added. The cuvette was capped, shaken for 1 minute, and left for 10 minutes for color development. After wiping, the sample was inserted into the colorimeter, and the "Read" button was pressed to display the nitrate concentration in mg/L. Clean cuvettes and careful handling of reagents were emphasized. If the concentration was too high, the sample was diluted and retested. This procedure ensured accurate nitrate measurements using the Hach DR/890 colorimeter.

2.4.9 Phospate

The HACH DR/890 colorimeter was used to measure phosphate concentration. The instrument was blanked with 10 mL of distilled water after entering program number 79. A PhosVer 3 phosphate powder pillow was added to 10 mL of the sample in a sample cell. The mixture was inverted several times for 15 seconds, allowed to stand for 2 minutes, and then inserted into the colorimeter. The phosphate concentration was displayed on the screen in mg/L.

2.4.10 Heavy metal

Analyses of heavy metals (Lead, Zinc, Iron, and Copper) in water were done by transferring 500ml of the water into a long beaker, adding 15ml of Conc. HNO3, evaporating on a steam bath to approximately 25ml and bringing the volume to 50ml with deionized water. The various heavy metals were analysed using the atomic absorption spectrophotometer (Buck scientific 210vgp).

3. Results and Discussion

3.1 Results of the Survey of Water Utility of Hall 3

This section presents the results of the survey of the water utility of Hall 3. The results are presented in form of water supply network diagrams and tables of nodes, pipe sections, pumps, reservoirs, valves and tanks properties.

3.1.1 Water Distribution Network of Hall 3

The water distribution network of Hall 3 is shown in the figure below.

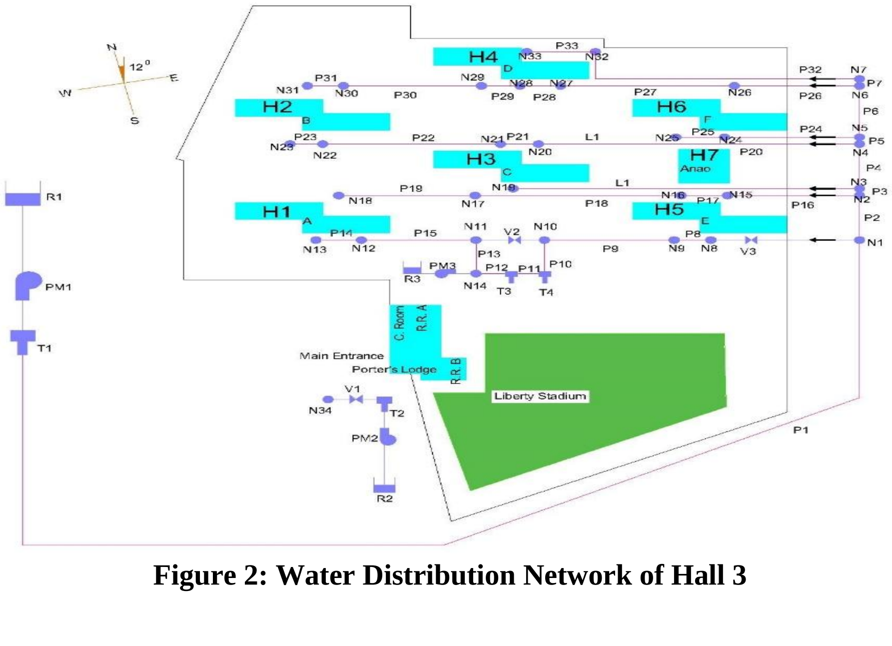

Figure 2: Water Distribution Network of Hall 3

The legend explaining the symbols used in the above figure is given below

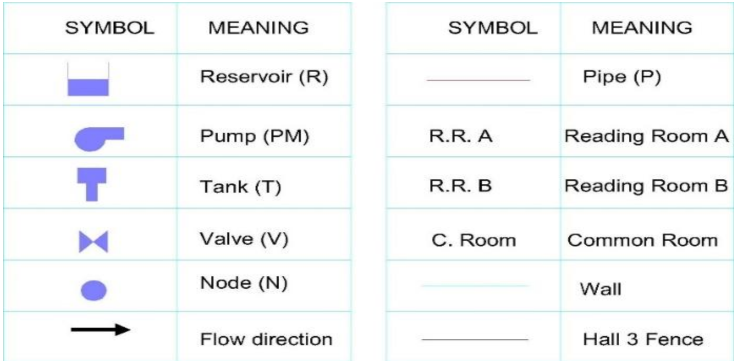

Figure 3: Legend for Water Distribution Network Drawing

3.2 Summary of Grading of Water Supply Appurtenances in Hall 3

The grading of the water supply appurtenances in the hostel are summarized in the table below.

Table 1: Summary of Grading of Water Supply Appurtenances in Hall 3

Appurtenance	Average Grading
Nodes	3.250
Pipe sections	3.610
Valves	5.000
Pumps	3.670
Reservoirs	3.333
Tanks	3.750

The grading of the nodes shows that the valves are in excellent condition. With an average grading of 5, they are the most highly graded among the appurtenances. The nodes are the most poorly graded appurtenance with an average grading of 3.333. Thus the nodes are in Fair condition. The tanks have an average grading of 3.750 which is very close to Good condition. Pipe sections in the water supply had an average grading of 3.610, while pumps had an average grading of 3.670. Thus the grading designation of pipe sections and pumps is between Fair and Good, but closer to Good.

3.3 Summary of Water Quality Test Results and Comparison with Standard

All standards are from NSDWQ except for the following parameters: Phosphate, DO, BOD, and TSS, which are from NDWQS.

Table 2: Summary of Water Quality Test Results and Comparison with Standard

Parameter	Water from Source	Water Sample: Block ID					Standard
		A	C	D	E	F	
Phosphate (mg/L)	0.216	0.177	0.183	0.183	0.194	0.194	< 0.024
Nitrate (mg/L)	0.764	0.744	0.736	0.738	0.683	0.730	< 50.000
Lead (mg/L)	0.0020	0.0022	0.0033	0.0029	0.0036	0.0025	< 0.0100
Copper (mg/L)	0.06	0.16	0.24	0.22	0.27	0.31	< 1.00
Zinc (mg/L)	0.01	0.03	0.00	0.00	0.00	0.01	< 3.00
Iron (mg/L)	0.14	0.14	0.13	0.18	0.17	0.14	< 0.30
DO (mg/L)	6.5	6.4	6.6	5.8	5.9	5.7	$6.5 - 8.0$
BOD (mg/L)	2.3	2.9	3.8	3.5	3.1	2.5	< 5.0
pH	7.8	8.7	8.3	8.2	8.0	7.9	$6.5 - 8.5$

Parameter	Water from Source	Water Sample: Block ID					Standard
		A	C	D	E	F	
E. Coli (counts/100ml)	0	0	7	22	13	0	0
EC (μS/cm)	3.7	21.5	15.9	20.7	24.9	26.0	< 1000
TDS (mg/L)	16.5	16.0	11.1	14.4	17.4	18.2	< 500
TSS (mg/L)	1	1	2	0	0	1	< 25
Turbidity (NTU)	2	12	7	1	2	4	< 5
Total Hardness (mg/L as $CaCO_3$)	6	6	8	6	8	8	< 150

3.4 Summary of Water Quality Indices of the Source and the Blocks in Hall 3

The table below shows the Canadian water quality index of the source and each block in Hall 3.

Table 3: Water Quality Indices of the Source and the Blocks in Hall 3

Location	Scope (A)	Frequency (B)	Amplitude (C)	Water Quality Index
Source	6.6667	6.6667	34.7812	79.1938
Block A	26.6667	26.6667	35.9057	69.9356
Block C	20	20	46.4754	68.5880
Block D	20	20	65.2174	58.9569
Block E	20	20	63.4819	63.4819
Block F	13.3333	13.3333	33.7090	77.6995
Average	--			**69.6426**

3.5 Discussion of Results

The results of the survey of the water utility of the hostel and the water quality tests are discussed in this section.

3.5.1 Results of the Survey of the Water Utility of Hall 3

The survey showed that the type of water supply network adopted in Hall 3 is the dead-end system. There are two sources of water supply in Hall 3.

1. Internal water supply
2. External water supply

*3.5.1.1 Internal water supply***:** The internal water supply consists of the two boreholes present in Hall 3. The first borehole is installed beside the main entrance of the hostel, while the second borehole is installed in front of Block C.

3.5.1.2 External water supply: The external water supply consists of the water supplied from outside the hostel. This is the major source of water supply in the hostel. About 90% of the junctions and nodes in the hostel are supplied water exclusively from the external water supply.

The water supply network of the hostel is a dead-end network. Stagnation can occur in a dead-end line. Dead ends are not considered to be best practice and should be avoided because they reduce fire flows, lead to the deterioration of water quality, and can cause corrosion. Dead ends can also affect water pressure, flushing operations, and water service during main repair and maintenance. Dead-end designs can cause serious degeneration of water quality and, in some cases, pipe materials, which can lead to water quality complaints and concerns. Potential problems include:

- a buildup of debris in dead ends;
- extended detention time, which can reduce chlorine residuals and create zones that are breeding grounds for bacteria and larvae; and
- taste and odour complaints that require extra preventive maintenance flushing.

The visual inspection of the water utilities showed that a large percentage of the water supply appurtenances in the hostel are in good condition. However, the service pressure in Block B is very low. This is due to the large distance between this block and the water main which is on the other end of the hostel. It was found out that Block E and Block F had higher service pressures due to their position in the water supply network; they are much closer to the main pipe of the water supply.

According to the Borehole staff at Queen Idia (Hall 1) Hostel, the external source of water in Hall 3 comes from a borehole in Tinubu (Hall 2) Hostel. Water from the borehole is pumped into an elevated storage tank. The water in the tank is distributed by gravity to Hall 1, Hall 2, and Hall 3. The main pipe circumvents Hall 3 halfway then splits up into 7 sub-mains that enter the hostel. The pipes do not pass directly to Hall 3 because that path contains a tarred road and the pipes may be damaged by traffic load due to vehicles.

3.5.2 Results of Water Quality Tests

The average water quality index was calculated as 69.6426. Thus the designation of the water quality index of Hall 3 is Fair. This means conditions of the water in the hostel sometimes depart from natural or desirable levels. It was observed that the water from the source and water in all Blocks considered had a high phosphate concentration. This could be due to the natural decomposition of rocks and minerals in the source water. This high phosphate content would stimulate the growth of plankton and aquatic plants.

Phosphates enter waterways from human and animal waste, phosphorus-rich bedrock, laundry, cleaning, industrial effluents, and fertilizer runoff. These phosphates become detrimental when they over fertilize aquatic plants and cause stepped-up eutrophication.
Eutrophication is the natural ageing process of a body of water such as a bay or lake. This process results from the increase of nutrients within the body of water which, in turn, create plant growth.

The plants die more quickly than they can be decomposed. This dead plant matter builds up and together with sediment entering the water, fills in the bed of the bay or lake making it shallower. Normally this process takes thousands of years.
Water from the source had the highest water quality index. This is because the water gets contaminated as it flows through the pipes. A broken pipe would easily allow the inflow of stormwater when it is not full with water or when water is not being pumped through it. This explains how broken pipes lead to contamination of the water supply in the hostel.

Block D had the lowest water quality index of 58.9569. This is possible because Block D is the last block to be supplied water by the water main. Thus there is a high chance of the water being contaminated before reaching the block.

4. Conclusions

The integrity of the water utility of Hall 3 has been assessed towards a sustainable supply of safe drinking water. The performance and condition of the water supply have been determined. The water supply utility of the hostel was observed to be fairly adequate. Thus it can meet current and future demand. The water quality index, as computed by the Canadian water quality index (CWQI), was fair. The grades of the appurtenances are between 3 and 5. This means on average the grading of the appurtenances is Good. The appurtenance with the lowest grade was the nodes. Thus the nodes in the hostel need maintenance.

4.1 Recommendation

Hall 3 water utility suffers from maintenance problems. The borehole beside the main entrance has been dysfunctional for about a year. If it is repaired and maintained it could serve as another source of water supply in the hostel. Thus it will help solve the problem of water scarcity in Hall 3.
Some pipes in the network are broken or leaking. This causes wastage of water resources and possible contamination of the water supply. It also leads to loss of head in the distribution system.

The type of water network employed in Hall 3 is the dead-end system. This system allows water stagnation in dead ends. Hence there needs to be regular flushing of the dead ends. A flush hydrant should be located near the end so stagnant water can be easily flushed out of the line.

A better system recommended for Hall 3 is the gridiron system due to the orderly arrangement of the blocks in the hostel. In a system laid out in a grid in which pipes are looped, instead of a dead-end design, water can flow from more than one direction when a high rate is required. Some sections of the water supply pipes in the hostel are located in the drainage. This poses a serious health threat as the pipes could be contaminated from the stormwater in the drains. It is recommended that the pipes be buried by the sides of the drains.

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