Current/ Future Potable Water Demand and Supply at the Federal University of Technology, Akure, Nigeria

¹Samuel B. Akeju, ^{*2}Ochuko M. Ojo and ²James R. Adewumi

¹Department of Works and Services, Federal University of Technology, Akure, Nigeria

²Department of Civil Engineering, Federal University of Technology, Akure, Nigeria

akejusam@yahoo.com | omojo@futa.edu.ng | jradowumi@futa.edu.ng

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Abstract- This study is aimed at assessing current and future potable water demand and supply at the Federal University of Technology, Akure (FUTA), Nigeria. The only source of water to the University community is ground water extracted through boreholes constructed at different locations in the University. Eighteen (18) storage and distribution reservoirs were assessed to assess their capacity to adequately supply water for the present and future population of students and staff within the institution. FUTA had a population of 28,419 in 2019, the staff made up 9.16% of the total population while the students constituted the remaining 90.84%. A 30-year population projection was made for both staff and students using the geometric increase method of population forecasting. The study revealed that the population of FUTA will grow to 62,280 persons in 2049 from 28,419 in 2019 assuming a constant growth rate of 2.65% while the current average daily water demand of the University community is 1,475.83 m³/day. The current yield of water from the boreholes in FUTA is 1,198.07 m³/day which is not sufficient to meet the daily water demands of the University community. The maximum possible yield from the boreholes is 2,443.68 m³/day under normal conditions involving stable power supply and adequate personnel. Furthermore, it is projected that by the year 2049, the average daily water demand of the University community would be 2,995.74 m³/day. The outcome of this study revealed that there is water shortage in FUTA and the situation would worsen as the years go by if adequate measures are not put in place. The construction of a dam and water treatment plant is recommended to meet the increasing water demands occasioned by increase in population.

Keywords- Borehole, Demand, Potable, Supply, Water

1 INTRODUCTION

The availability of reliable and clean supply of water is one of the most important determinants of human health (Parson and Jefferson, 2006; Ojo, 2016). Water is an indispensable constituent of life (Osunkiyesi, 2012). Worldwide, large number of people suffer from fresh water shortage due to population growth (Zhu *et al.*, 2015; Ni *et al.*, 2018). According to WHO (2011), diseases related to drinking-water contamination represent a major burden on human health and the interventions to improve the quantity and quality of drinking water provide significant benefits to health.

Water availability is one of the greatest global sustainability challenges. Water is not available in adequate quantity and quality in many areas and water shortfalls are expected to increase as population and industries increase. Forty percent of the world's population live in areas of water scarcity and an estimated 50% will be affected by 2025 (Mueller *et al.*, 2015). It is predicted that dispute over water would be a source of future wars (Rasler and Thompson, 2006). Of all sources of freshwater on the earth, groundwater constitutes over 90% of the world's readily available freshwater resources (Boswinkel, 2000). Groundwaters are very reliable water sources for domestic and agricultural irrigation needs (Akpoborie *et al.*, 2008; Haruna *et al.*, 2008; Shymala *et al.*, 2008; Okeola *et al.*, 2010).

Groundwater plays an important role in both private and public water supplies all over the world (Ibeh and Okplenye, 2005; Pradhan and Pirasteh, 2011; Ojo, 2015). It is widely used as a source for drinking water supply (Zekster and Everett, 2004) and is usually extracted through wells and boreholes. This is because boreholes are resistant to many forms of natural and manmade contaminants and the narrow opening at the top of the borehole often prevents contamination of the water source or damage to the pump components below ground (WHO, 2011). In spite of the availability of groundwater, the challenge of ensuring usable water in sufficient quantities remains a primary issue in most developing countries (Amangabara and Ejenma, 2012).

The aim of this study is to assess the current and future potable water demand and supply in the Federal University of Technology, Akure (FUTA), Nigeria. In the past five years to one decade, FUTA has witnessed remarkable expansion in terms of population growth and developmental activities such as construction of office complex, hostels, laboratories, lecture theatres, roads, establishment of factories and business centres, agricultural activities and many other anthropogenic activities across the campus. The Department of Works and Services of the Federal University of Technology Akure is saddled with the responsibility of supplying water for various use in the institution's hostels, administrative offices, academic buildings, staff quarters and other buildings. The Department is currently faced with the challenge of meeting the water needs of staff and students of the University. There is a perceived shortage of water supply and poor sanitation. This problem is anticipated to increase if proper evaluation is not done to assess the state of water demand and supply in FUTA

*Corresponding Author

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particularly with the massive construction of new students' hostels and other developmental structures within the institution. Thus, assessing the current and future water demand and supply systems in FUTA is imperative.

2 METHODOLOGY

2.1 STUDY AREA

The study was carried out at the Federal University of Technology, Akure (FUTA), Ondo State, Nigeria. It is located in Akure town, the capital of Ondo State, Nigeria. It lies between longitude 5°06'E to 5°38'E and between latitude 7°07'N to 7°37'N. It has distinct wet and dry seasons with the onset of rainfall during the month of March and conspicuous decrease in amount during the month of November. The annual rainfall varies between 1500 mm and 3500 mm with mean annual temperature ranging from 24 °C to 27 °C, while the mean relative humidity is over 75% percent. Topographically, FUTA is composed of mostly lowlands and few rugged hills and is located within the sub-equatorial climatic belt with tropical rain-forest vegetation. FUTA has a population of 28,419 comprising of staff and student as at 2019. The major source of water in FUTA is from boreholes which are drilled at different points on the University campus. The Satellite imagery of FUTA is shown in Figure 1.

Fig. 1: Satellite Imagery of FUTA

2.2 CONNAISSANCE STUDY AND DATA COLLECTION

A thorough reconnaissance study was carried out on all the existing water infrastructures (including boreholes and reservoirs) to review their performances. In the process, data were collected which were used in determining the adequacy and degree of functionality of the infrastructures in the production and distribution of potable water supply to the University community.

2.3 CURRENT WATER DEMAND ANALYSIS

The current population of students was obtained from the Admissions, Academic Planning and Students Affairs offices while the population of staff (both academics and non-academics) were obtained from the Directorate of Personnel (Human Resource Units) of the university. The future population for 30 years was projected using the geometric increase method of population forecasting given in equation 1.

$$P_n = P \left(1 + \frac{i}{100}\right)^n \quad (1)$$

where: P_n is Projected Population in 'n' years,
 P is the Present Population,
 i is the Population growth rate in percentage,
 n is the Number of years to be projected into

2.4 PER CAPITA WATER DEMAND

The students' population was classified into two groups namely residents and non-residents. The residents were obtained to be 15% of the student total population while the non-residents make up the remaining 85%. The staff population was also classified into two groups namely residents and non-residents. Five percent increase every 5 years was assumed for the residential staff. Visitors' population was assumed to be 5% of staff and students' population. The daily per capita water demand for non-residents staff and students was assumed to be 0.04 m³ (40 litres) while that of resident staff and students was assumed to be 0.08 m³ (80 litres). Other water demands which include fire hydrants, toilets, laboratories and workshops was taken as 10% of the total domestic demand.

2.5 BOREHOLE DISCHARGE AND RESERVOIRS CAPACITIES

The discharge rate of the borehole was determined using a 20 litres calibrated bucket and a stop watch. The amount of water discharged per minute was measured. Also, each borehole water production was taken for three days using water reading meter. The average volume of water obtained from each borehole was determined. The water reservoirs capacities were obtained from the Directorate of Works and Services of FUTA. These were further used in calculating the storage capacities of infrastructures currently available.

3 RESULTS AND DISCUSSION

3.1 FUTURE POPULATION PROJECTION

Population is a governing criterion for determining the capacity of a water supply system. Thirty years population projection for FUTA is given in Table 1 with the proportion of staff to students. The thirty years population projection covers years 2019 to 2049. The population in 2013 is also shown and a growth rate of 2.65% was assumed. Analysis of residential and non-residential staff and students is presented in Table 2.

Table 1. Population projection for both staff and student at interval of 6 years

Year	Total Population	Student	Staff	Growth Rate
		(90.84%)	(9.16%)	
2013	24,292	22067	2225	2.65%
2019	28,419	25816	2603	2.65%
2025	33,247	30202	3045	2.65%
2031	38,896	35333	3563	2.65%
2037	45,504	41336	4168	2.65%
2043	53,235	48359	4876	2.65%
2049	62,280	56575	5705	2.65%

Table 2. Analysis of residential and non-residential staff and students

Year	STDP	RSTDP (15%)	NRSTDP (85%)	SP	RSP (5% increase every 5 years)	NRSP
2013	22067	-	-	2225	-	-
2019	25816	3872	21944	2603	60	2543
2025	30202	4530	25672	3045	63	2982
2031	35333	5300	30033	3563	66	3497
2037	41336	6200	35136	4168	69	4099
2043	48359	7254	41105	4876	73	4803
2049	56575	8486	40089	5705	77	5628

STDP- Students Population, RSTDP – Residential Students population, NRSTDP - Non-residential Students population,
SP - Staff Population, RSP - Residential staff population, NRSP - Non-residential staff population

Table 3. Future average daily water demand for 2019-2025

Demand source	Daily water required/capita in m ³	Estimated daily water demand (m ³)				
		2019-2025	2025-2031	2031-2037	2037-2043	2043-2049
RSTDP	0.08	362.4	424	496	678.88	678.88
NRSTDP	0.04	1,026.88	1,201.32	1,405.44	1,644.2	1,789.32
RSP	0.08	25.2	26.4	27.6	28.8	30
NRSP	0.04	119.28	193.88	166.72	192.16	225.2
Visitors						
(5% of STDP and SP)	0.2	33.24	38.90	45.50	53.24	62.28
Total		1,567.00	1,884.50	2,141.30	2,597.3	2,723.40
Others (10% of Total)		156.70	188.45	214.13	259.73	278.57
Grand Total		1,723.70	2,072.95	2,355.39	2,857.01	3,064.27

STDP- Students Population, RSTDP – Residential Students population, NRSTDP - Non-residential Students population,
SP - Staff Population, RSP - Residential staff population, NRSP - Non-residential staff population

From Table 2, it can be seen that FUTA witnessed an increase in population of 4,127 staff and students from 24,292 in 2013 to 28,419 in 2019. The population of resident staff in 2019 was 60. This population was projected to 77 in 2049 assuming an annual population increase of 5%. The results revealed that the population of FUTA will grow to 62,280 persons in 2049 from 28,419 in 2019 assuming a constant growth rate of 2.65%.

3.2 PROJECTED WATER DEMAND IN FUTA

The future water demand in FUTA was computed using the projected population on the basis of planning up to 2049. Table 3 presents the future water demand in FUTA in years 2019 to 2025, 2025 to 2031, 2031 -2037, 2037 to 2043 and 2043 to 2049 respectively. A Summary of daily water demands is presented in Table 4.

From the tables, the estimated water consumption per day will increase from 1,723.70 m³ in 2019 to 3,064.27 m³ in 2049 which is 77.8 % increment of the current estimated water consumption per day. More water supply infrastructures will therefore be needed as the overall population of FUTA increases.

Table 4. Summary of daily water demand

Year	Estimated daily water demand m ³
2019	1,475.83
2019-2025	1,723.7
2025-2031	2,072.95
2031-2037	2,355.39
2037-2043	2,857.01
2043-2049	2,995.74

3.3 BOREHOLES YIELD

The yield from the different boreholes is presented in Table 5. The Table shows a range of 20 litres/min to 327 litres/min with the highest yield obtained from the borehole located at the fire station area. The total water yield per day is 1,697 litres/min which is equivalent to (1,697 × 60) = 101,820 litres/hr while the current water pumps yield per day is 101,820 × 24 = 2,443,680 litres which is equivalent to 2443.68 m³ under normal conditions involving stable electricity supply and adequate personnel availability.

Table 5. Maximum Possible Borehole yield

Borehole Code	Pump Yield (Litres/Min)
BH01	20
BH02	NA
BH03	58
BH04	56
BH05	60
BH06	20
BH07	27
BH08	20
BH09	30
BH10	78
BH11	57
BH12	62
BH13	60
BH14	50
BH15	30
BH16	20
BH17	30
BH18	50
BH19	100
BH20	Abandoned
BH21	327
BH22	263
BH23	249
BH24	NA
BH25	30
Total	1,697

NA – Not Available

(Source: FUTA Directorate of Works, 2017)

The daily volume of water produced by the boreholes for three consecutive days is presented in Table 6. BH06 has the least water yield of 5 m³ and this was observed on the third day while BH21 have the most water yield of 294.3 m³ observed on the first day. The difference in water yield may be due to power supply at the different location. BH21 has a very high-water yield because of constant electricity supply and by virtue of being an industrial borehole.

From Table 6, the average daily water produced by the boreholes is 1,198.07 m³ as shown in equation 2.

$$\text{Average daily water produced by the boreholes} = \frac{1288.3 + 1146 + 1160}{3} = 1,198.07 \text{ m}^3 \quad (2)$$

3.4 STORAGE AND DISTRIBUTION TANKS

The boreholes are connected through a network of pipes to the storage and distribution tanks for onward transmission to the consumers. The storage capacities of the distribution tanks are presented in Table 7. The total capacity of the distribution tanks is 1,358.6 m³ with SDT 3 having the highest value of 267 m³. This is by virtue of the fact that it is the largest and the major distribution tank on campus.

Table 6. Daily water production for three consecutive days

Borehole Code	1 st Day (m ³)	2 nd Day (m ³)	3 rd Day (m ³)
BH01	18	16	19
BH02	NF	NF	NF
BH03	52.2	48	53
BH04	50.4	52	51
BH05	54	45	49
BH06	18	20	5
BH07	24.3	22	25
BH08	NF	NF	NF
BH09	27	24	30
BH10	70.2	65	69
BH11	51.3	53	52
BH12	58.8	60	59
BH13	54	57	53
BH14	45	47	44
BH15	27	29	27
BH16	18	25	20
BH17	27	20	23
BH18	45	42	44
BH19	90	85	89
BH20	NF	NF	NF
BH21	294.3	192	204
BH22	NF	NF	NF
BH23	NF	NF	NF
BH24	NF	NF	NF
BH25	27	25	23
TOTAL	1,288.3	1,146	1,160

BH – Borehole NF- Non- Functional

Table 7. Storage and Distribution tanks

S/N	Storage and Distribution Tanks	Capacity (m ³)
1	SDT 1	125
2	SDT 2	93
3	SDT 3	267
4	SDT 4	55
5	SDT 5	100
6	SDT 6	100
7	SDT 7	25
8	SDT 8	75
9	SDT 9	12
10	SDT 10	55
11	SDT 11	75
12	SDT 12	90
13	SDT 13	33.6
14	SDT 14	217
15	SDT 15	8
16	SDT 16	12
17	SDT 17	8
18	SDT 18	8
	TOTAL	1,358.6

SDT – Storage and distribution tank

4 CONCLUSIONS AND RECOMMENDATION

This study which was aimed at assessing current and future potable water demand and supply at the Federal University of Technology, Akure (FUTA), Nigeria revealed that the current average daily water demand of

the University community is 1,475.83 m³. The present yield of water from the boreholes in FUTA is 1,198.07 m³ which is not sufficient to meet the present daily water demands of the University community. The maximum possible yield from the boreholes is 2, 443.68 m³ under normal conditions involving stable power supply and adequate personnel availability.

The study also projected that by year 2049, the average daily water demand of the University community would be 2,995.74 m³. The outcome of this study has shown that there is water shortage in FUTA and the situation would worsen as the years go by if adequate measures are not put in place. The construction of a dam and water treatment plant is recommended to meet the increasing water demands occasioned by increase in population.

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