

EVALUATION OF QUANTITY OF WATER SUPPLY IN MINNA METROPOLIS

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ABSTRACT

The quest for portable and safe drinking water has continued to be a challenge to most Governments of West Africa. Since its inception in 1976, the state water board constructed three treatment plants in minna metropolis, the last been in 1992 with a total capacity of 77mlpd including Bosso treatment plant to cater for a population of 193,300. This volume is expected to fill all the eight storage elevated tanks per day. The aim of this paper therefore is to provide Analysis and hydraulic evaluation of the supply system considering an increase in population, rise in living standard of the populace and rapid urbanization. Remote Sensing was used in the Estimation of demand and karman- Prandtl- Colebrook Nomogram were used for pipe sizing. The studies revealed the capacity of the tanks to be insufficient and were even underutilized primarily due to connections from the transmission mains. The study also identified inadequacy of transmission pipes' internal diameter, and therefore concludes by recommending for a re-design of the system.

Keywords: water demand, water supply, population estimate, pipes network.

1.0 INTRODUCTION

As the world's population is increasing, which give rise to rapid urbanization, environmental issues will continue to occupy centre stage in the development debate. Foremost, among these issues will be the issues of water supply which is essential for human life, economic development, social welfare and environmental sustainability.

Currently, the availability of this (water) vital resource is by no means assured for large sections of the world's population. Today, more than one billion people do not have access to an adequate supply of safe water and 1.7 billion people do not have adequate sanitation. Moreover, the poor pay the most for water and suffer the greatest in forms of impaired health and lost economic opportunities. In developing countries (e.g. West Africa) contaminated water causes millions of preventable deaths every year, especially among children. Generally, a country or

region is said to experience periodic water stress when its annual supplies of water per capita falls below 1,700 cubic meters, (Nasir 2001).

Today some 22 countries have renewable water resources of less than 1,000cubic meters, and 18 have less than 2,000 cubic meters. The expected growth of population over the next 30 years to at least eight (8) billion and increase in living standards and economic activity will combine to create an enormous increase in the demand for water. By 2025 as many as 52 countries with some three (3) billion people will be water-stressed,(Nasir 2001)

Furthermore, rapid urbanization is placing unprecedented pressures on water supply and quality. Between 1950 and 1990, the number of cities with population of more than one million nearly quadrupled from 78 to 290, adding some 650 million people. In the next few years, half the world's population will live in cities.

By 2025, 90% of population growth will have taken place in urban areas, increasing the demand for water of suitable quality for domestic, municipal and industrial use and for treatment of waste. Today in the developed world, industry uses between 40% and 80% of total water withdrawals, comparable figures for developing countries are 2-5%. This figure can be expected to grow significantly. Greater industrial use will also lead to more problems of water quality. Income growth will also put pressure on household water use because the rich use water than the poor,(Nasir,2001).

Background to the study.

Minna, the Niger state capital has over the years experienced and still experiencing water scarcity primarily due to rapid increase in population and urbanization.

The pipe network system has nearly 70km of pipe that serve as transmission mains and were made up of ductile iron, with size varying from 300mm to 900mm. The distribution main with a diameter ranging from 100mm to 400mm has a total length of 210km. With a combine pumping from the three pumping stations at 558m³/hr (2 Nos), and 350m³/hr, it is possible to supply water for twelve hours daily. However, our on-site investigation revealed that due to epileptic power supply, only two out of three pumps are pumping for only four hours a day.

This records a slight improvement when compare to years back, where the supply is only four hours a day and to specific area on rationing bases. (Musa, 2014).

The sources of Minna water supply are Chanchaga water works and Bosso treatment plant with a capacity of 77,000m³/day and 1200m³/day respectively. However, as at today these design capacity were under-utilized due to inefficiency of pumps which operates at about 20% over the years. Recently the present Government has replaced the aging pumps, but yet the water supply is still inadequate to even the areas that are connected to the system. Vandalization of mains contributed to the overall failure of pumps to supply water to the storage tanks as designed, thereby creating a 'NO PRESSURE' zones in the distribution system.

Most of the supplies from Chanchaga and Bosso treatment plant are by gravity with little having direct pumping (as shown in table 1). There is only one booster station at Dutsen-kura tank (Muhammad 2014). Another problem of inadequate supply is lack of metering.

Currently the board is operating manual billing of customers every month, ranging from ₦1000- ₦2000 per resident in Minna metropolis. There are about 12,245 residents being supplied by the board and about 359 commercial and industries (which includes, schools and institutions, hotels, car wash, pharmacies, package water and block industries), charging them ₦200/m³. Others, are water tankers of 9000 litres, 7000 litres, and 6000 litres, and water vendors popularly known as 'MAI RUWA'.

The distribution network of Minna water supply is divided into 5 zones. Zone A, runs from Chanchaga town, Tungan goro, up to city gate with 2446 households and commercials of 72. Zone B comprises of Kpakungu to tipper garage having 1620 and 40 commercials respectively. Zone C consist of Tunga with 3,846 and 118. Zone D, runs from Maitumbi down to F/layout having a total of 2,820 and 61 commercials.

The last zone is Bosso to Tudun Fulani with 1,513 and 68 commercials. Reservoirs/tanks were constructed at strategic location with high level terrain so as to comprehend the distributions network by gravity. Each tank was designed to supply to certain area covering the whole areas and wards of Minna. The 10,000m³ tanks at Dutsen Kura are meant to serve Bosso Estate,

Dutsen Kura Hausa and Dutsen Kura Gwari police Headquarter Fadikpe, London Street, Bosso Low-cost and Kwasau Primary School Area.

Similarly, the tank at Tunga near Shiroro Hotel, with a capacity of 2000m³ is meant to serve, Tunga low-cost, Barkin Saleh, Shiroro road Deeper life church road and Shiroro Hotel area like, governor's residence at Talba crescent off peter sarki road and surroundings, Kolawole road etc. takes their water directly from the rising mains. Table 1.0 shows the properties of the reservoir.

Population of Minna

The national population commission could not give the exact estimate of Minna metropolis, the census was conducted only on local government basis, and Minna is beyond Chanchaga local government (with HQ at Minna) and not fully covered Bosso local government with HQ at Maikunkele. However 1991 census gives 190750 (Sanusi 2006).

Muhammad,(2014) gives Minna population 358295, while sanusi (2006) gives 440250 in 2002. Also populationstatistics.com estimated population of Minna in 2019 to be 434,000 with 440250 in 2002 (sanusi 2000) at 7.9% growth rate surely gives higher estimation in 2019.

In this paper, the population of Minna metropolis was estimated using remote sensing, GIS technique. Water demand and requirement are function of population once population (i.e number of persons to be served) estimates is far below the actual per capital demand and requirement, then the system will fail. The per capital demand of Minna varies from areas of high living standards (i.e with water system sheer, bath tub toilet, kitchen sink gardener watering car washing) to area of medium standard of living. These areas like, G.R.A. F-layout, Tunga Low-cost, Bosso Estate, Bosso Low-cost brighter school area, commissioners quarters, Zarumai, London road, Okada road, farm centre, Army Barrack and Up-hill are area etc. are considers to be of high living standard.Areas with medium water usage are; New Tunga Chanchaga town, Tunga Gauro,M I Wishishi Estate, Talba Quarters, Bay clinic road, Niteco road Fadikpe, Dutsen Kura Hausa, Dutsen Kura Gwari, Morris fertilizer, Bosso town, unguwar Biri, Tayi village and some parts of Maitumbi.

Areas with or without water closet and may not possibly use water to flush toilet and shower system of bathing are Kpakungu Al-bishir, Shanu village, Gidan Mangoro, Sauka Karhuta, Limawa, Unguwar Daji, Kwalkwata, Marikici, and MYPA school area.

The aim of this paper therefore, is to provide an up – to – date assessment of the system including the hydraulic design to ascertain the quantity of water needed in Minna. Metropolis using remote sensing.

2.0 MATERIALS AND METHOD

The study area:

Minna city is the capital of Niger State in North central Nigeria location at $9^{\circ}38'06''$, Lat. N and $6^{\circ}32'30''$ E Long., and is approximate 324km^2 (Muhammad 2014), with developed area of 125km^2 . Though, Muhammad (2014) opined 324km^2 , it is pertinent to note that Minna is the capital of Chanchaga local government area, but its area of water supply extended to cover some part of Bosso local government area including the Chanchaga town where the water work is located. However as at today, the total developed land area is beyond even 125km^2 . In fact, a declaration was made by previous and present government that Minna metropolis should stretch 20km from the centre of the city (Mobil Roundabout) resulting to about 1600km^2 for the purpose of this analysis, however the existing pipe network cover up to 125km^2 .

Population Estimates Based on Dwelling Units

The method of estimates based on dwelling units is made possible only if a large or medium scale aerial photography is available. In this paper Imagery of the study area was captured and measured through the use of Google Earth and ARC GIS software. Areas served by each tank was captured and the dwelling type was identified and counted.

The number of persons per dwelling was sampled through field survey, and compared with studies carried out in Yola town Adamawa state by Bashir, *et al* (2016). However the study adopt 7 persons per dwelling unit as obtained from Niger state water board headquarter(NSWB). An average plot size in Minna ranges from 15m x 30m to 30m x 30m of which per hectare gives an average of 9 to ten plots(units) including green areas.

Water Demand and Water Requirement

The study area were classified in to three zones, that is highly dense areas (with low water consumption as a result of low life styles), Medium dense areas (with medium water requirement), and low dense areas (with high water requirement due to high living standards).

The average water demands of these areas were obtained and their overall average was used in the calculations of per capita demand.

Table 1: Service reservoirs with equivalent pipe length and diameter

Diameter (mm)	Length (m)	Types	Reservoir	Capacity(m ³)	Area served
300	9624	DI	Dutsen Kura	10,000	Dutsen Hausa Dutsen Kura Gwari, Bosso Loc-Cost, Bosso Estate Shanu village Police London street
300	5665	DI	Biwater	4,500	Shango, Army barrack, new seet gidan madara kuna
700	7451	DI	Shiroro	2,000	Tunga, Tunga Low-Cost, Shiroro Road, Niteco Road
	9617	DI	Up hill tank	7000	Minna central, Maitumbi Bosso road 123 quarters old airport road okada road commission quarters
600 &450	1407 &11024 &9617	DI	Paida tank	4000	Unguwan daji unguwan sarki, F- layout, zarumai, abayi close.
450	7925	DI	INEC	1000	Police barrack, bay Clinic road, tunga sabon titi, tunga dan boyi & railway quarters
300	7125	DI	Tunga top medical	2000	Tunga, top medical road& sabon gari
300& 400	1648 &889	DI	From paida to bahago	1000	Bosso A, Goggo mai lalle, old ATC, old Abbatoir and MTP 59

Sources; Niger state Water Board

Method of pipe sizing

The analysis and design of existing pipeline include assigning demand to nodes that are connected to the transmission line before the reservoir (tank) are filled up. From the tank, there are also distribution mains that distribute water to the area intended to serve and the configuration of the system used is branched system.

The determination and computation of the diameter of pipes is carried out using Nomogram and head loss coefficient is Hazen-William coefficient of 140 for the pipes type. The existing pipe factor of 0.1 for PVC and 0.4 for Asbestos cement) were used in the design.

The head loss or slope is given by;

$$f = \frac{I_{high} - I_{low}}{\epsilon L} \text{-----(1)}$$

Where I_{high} = highest elevation of the pipe in metre

I_{low} = lowest elevation of the pipe in metre

ϵL = Summation of length of pipes. With the flow rate Q in L/s and head loss S in metres for each Node) the corresponding diameter of the pipe is obtained i.e ϕ as a $f(Q, S, K)$ from the nomogram.

A excel model called BOX FORMULA was also used to compare the result obtained from the nomogram. It is given by;

$$d = \left(\frac{q^2 \times 25 \times L \times 10^5}{H} \right)^{1/5} \text{-----(2)}$$

Where d = pipe internal diameter in (mm)

q = flow rate in l/s

H = Head or pressure (m)

L = effective length = Actual length + equivalent pipe length (m)

3.0 ANALYSIS AND DISCUSSION

Domestic demand:

The maximum daily water consumption occurs before 8:00am to 2:00pm. Therefore, the average domestic needs for the three categories as listed above i.e. high living standard, medium and low living is 200 litres per capital for high, 120 litres per capita for medium and 80litres per capita for low.

$$= 200 + 120 + \frac{80}{3} \Rightarrow \frac{400}{3} = 133 \text{ litres/capital/day.}$$

Hence ,other demands can be taken as 50% of domestic demand. Therefore per capita demand can be taken as 200 L.

The population of Minna as at today can be estimated using 7 persons per household = 70 persons /hectare. The declaration of 20km from centre of town is covers a total of 1600km², that is from mobil roundabout 20km to north towards Zungeru road, covers the entire Maikunkele community to west along Bida road reaches F.U.T Minna main campus covering the whole of Gidan mangoro Beganu, Kolkata, shanu village and beyond then to the east towards maitumbi –kuta road, it extend up to shaguna with about 16km out of 20km declared, already developed. To the south the 20km extend to paiko junction with totungo and Pago already developed.

Therefore up to 80% of 1600km² is already developed as at today, which amount to 1280km² which is equal to about 128,000 hectares. Let us assumed 50% of this area which is 640km² (64000ha), the population can be 4,480,000.

Musa (2014) opined that Minna is 324km² = 2,268,000, while sanusi (2006) stressed that in 2002 Minna is 440,250 and 1991 census gives 190750 of which using arithmetic mean method of forecasting and the design period of 27 years (1992 – 2019), yields 1,045,644 people.

Therefore, by estimation, the population of Minna cannot be less than 1 million people.

Hence, Total water demand = 1,045, 644 x 200 = 209,128,800 litres/day
= 209,128m³/day.

Table 2. Water requirement for storage tanks.

Storage tank	Tank capacity(m ³)	Consumption /population	Litre/capita/day	Required water (m ³)	Remark
Dutsen Kura	10,000	357,350	200	71,470	86%
Shiroro	2000	23100	200	46,200	96%
Top medical	2000	40,320	200	8,064	75%

Bi water	4500	170,590	200	34,118	87%
Uphill	7000	42,350	200	8,470	17%
Paida	4000	44,800	200	8,960	55%
Bahago	1000	26,950	200	5,390	81%
Inec	1000	30,660	200	6,132	84%
Total	31500	736120		147224	

The table 2, above shows that almost all the storage tanks are below storage capacity to supply the areas they are designed to serve. Uphill or IBB tank records slightly above the storage volume by 17%. This is due to the higher volume of 7000m³ it is storing.

However with a total combine pumping rate of about 1466m³/h from the pumping stations, it can take almost 24hr to fill all the tanks (with total volume of 31500m³). While the pumps will take 4 days to fill the new volume of 147224m³ furthermore there are areas that has direct supply from the main . The dutsen kura reservoir, though with higher storage volume ,is below requirement by more than 80%. The area covered by this reservoir has a well distributed connection with medium and low living standards which give rise to high water demand.

Shiroro Tank located near Shiroro Hotel, has the highest water demand of almost 100%. This indicates that people has changed their life style by demolishing and constructing modern buildings that require more water, while the area remain the same. All the connection in this area remain the same since commissioned.

Chanchaga town , Tungan gwauro Army Barrack, College of Education up to City Gate were served by direct supply from the water works.

Table 3: Result of Analysis

Tank supplied	Demand m ³ /day	Slope %	Flow rate L/S	Type	Diameter mm
Dutsen Kura	71,470	-0.8	827	D1	1200
Shiroro	46200	-0.4	535	DI	1000
Top medical	8,064	-0.8	93	DI	450
Bi water	34118	-0.8	395	DI	900
Uphill (IBB)	8,470	-0.8	98	DI	500
Paida	8960	+0.6%	104	DI	500
Bahago	5,390	-1.7%	62	Di	400
INEC	6132	-0.8%	71	A1	400
Direct supply to Chanchaga	1400	-0.2	16	PVC	
Army Barrack	2466	+0.2	28.5	AC	400
T/gwauro	2500	+0.2	28.9	PVC	400
College of Education	532	+0.6	62	AC	250
Shango	1064	0.2	124	AC	400

4.0 CONCLUSION:

In this study, the analysis of minna water supply has been carried out using available data obtained of Niger state water board and ministry of land. The population estimates, which is the main factor of water supply, was obtained by considering the areas that are already developed, and total water demand was calculated. The results of the analysis revealed a wide gap between the current water supply and water demand. The pipes' sizing was also carried out using a nomogram of 0.1mm for PVC and 0.4mm for ASBESTOS pipe respectively. The result indicates a slight increase in the internal diameter, which calls for a redesign of the system for optimum supply.

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