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ASSESSMENT OF WATER CONSUMPTION PATTERN IN ILORIN, KWARA STATE, NIGERIA

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ABSTRACT

This report presents the outcome of a survey of water use pattern in Ilorin, Kwara State, Nigeria. The water use pattern study extends to various water consumers such as residential, institutional, commercial and industrial. The study was conducted through questionnaire survey and oral interview which centered on water demand and uses. Most residents were found to use between 46 to 115 l/c/d. The high rates were common in low density areas and the low rates in medium and high density areas of the city. The daily values for commercial, industrial and institutional facilities sampled within the metropolis were 75,535; 188,735 and 161,680 litres respectively. Moreover, public water distribution system is not adequate, because majority of consumers still source water from wells or boreholes to meet their basic needs. Some mathematical models have been generated which could be used to estimate water need for planning and operational purposes. The results of the models show that water use by some categories of consumers can be estimated knowing certain variables and coefficients.

Keyword: Water use pattern, Water consumer, Water demand and Statistical tests

1.0 Introduction

Rapid growth in water demand is common in developing countries. The conventional practices of planning, designing and managing water supply systems requires regular review and adjustment. Determining how much is needed and is one of the first steps in providing that supply. Providing enough water to meet everybody's needs may be difficult in the short-term so water can be made available in stages. Continuous checking – including talking to the various users of the supply (especially women) will enable limited resources to be focused effectively. Providing water is never free; the water needs to be collected, stored, treated and distributed. Providing too much water is a waste of money. Taking too much water from a limited source may deprive people elsewhere of water and have adverse environmental and health impacts (Reed, 2005). Hence, evaluation of municipal water use becomes very essential and needs to be reviewed on regular basis. However, Gleick (1996) opined that at least 50 l/c/d are required to meet human and ecological needs, which include 5 l/c/d for drinking in tropical climates 20 l/c/d for sanitation, 15 l/c/d for bathing

and 10 l/c/d for food preparation. There are many factors that contribute to the total water consumed in a community and households. Arbues, et.al (2003) examined the main issues in literature on residential water demand. They analyzed several tariffs and their objectives and identified water price, income or household composition as crucial determinant of residential water consumptions. The rate of water demand depends on the socio-economic standard of the people, the level of education and development, the nature of prevailing climate and hygienic characteristic of people (Gilg and Bars, 2006; Arbues, et.al, 2003; Schleich and Hillenbrand, 2009; Mohammed, 2008). Water demand is not limited to domestic use only, but it is of various forms and for other purposes such as commercial, industrial, agricultural and public uses. Hence, water demand can be defined as the amount of water required to satisfy all human activities such as domestic, agricultural, industrial as well as firefighting.

The demand for water depends on variables linked to human needs and behaviour and changes over time and space. It has been known that the variation in water demand is due to some factors, such as geographical location, types of community,

population, cost, water management and economic status of the communities as well as the demographic characteristic of the area (Bouwa, 2000). Davis (2003) established a work plan for developing a water demand forecasting model which proposes a systematic methodology for forecasting municipal and industrial, (residential and non-residential, public and self-supplied) water demand throughout the state (by planning, area or county) based on an assessment and analysis of available data. It was stated that the selection of a water demand forecast methodology is a function of : planning objective, available data and available resources. Estimating water demand requires an important amount of data (Garcia and Reynaud, 2004). Hence, for effective water demand study, planning and designing, the total water is usually estimated from the aggregate of maximum water plus losses that may be envisaged. Several studies have identified the numerous factors that will assist the policy-makers in proper water demand management (Mohammed, 2000; Randolph and Troy, 2008; Gilg and Barr, 2006; Gomez-Limon, et.al, 2000, Gumbo, et.al, 2003; RenWick and Green, 2000; Mulwafu, et.al, 2003).

Water demand calls for planning with consideration being given to the use of non-conventional sources of supply. As a result, there will be a substantial increase in water costs and the problem of water supply can no longer be simply seen as development of new sources. Lack of data has been identified as the principal factor that is hampering proper and adequate water demand estimation in our society. Lack of metering has been identified as one of the reason that militates against efficient use of water because; the consumers and planners have no proper bases and criteria in defining their actual water use (Bithas, 2008). The review of the literature on water demand showed that adequate data has been identified as necessary tools in proper planning and water demand management and studies (Alsharif, et.al, 2008; Zhou, et.al 2002; Schleich and Hillenbrand, 2008; Ruijs, et.al, 2008). This work will address the growing interest in the evaluation of water demand and need to pay careful attention to modelling and forecasting water demand in the future based on the principal factors that have been identified to affect the various water types of water consumers. Demand models provide simplification or abstraction of complex physical reality and the processes involved in it, and serve as tools in the solution demand forecasting problems. The choice of an appropriate approach to water demand modelling play a vital role in making planning and management decisions in water supply sector.

Ilorin, like many other cities in Nigeria does not have accurate water demand figures that could be used for the design and proper planning of the water supply system. Hence, this work aims at evaluation of water consumption pattern in Ilorin in order to establish water consumption rates for various consumers such as domestic, institutional, commercial and industrial. The results of which could be useful for the purpose of upgrading the water supply scheme, planning expansion of water treatment plant, design of pumping stations, and the design of storage and distribution facilities for the metropolis.

2.0 Methodology

2.1 Data Collection

Questionnaire method was adopted to facilitate the estimation of water use in the city. Set of structured questions were drawn up for the households in each of the study areas. The study areas were categorized according to population into low, medium and high density areas. Aside the residential consumers, other areas of use were divided into commercial, institutional and industrial users.

Seven hundred (700) households were randomly selected for the residential water use survey. The residential areas were categorized as low, medium and high density areas. Two hundred (200) houses were randomly selected in the low density areas while three hundred (300) houses were selected in the medium density areas, the rest were in the high density areas. In return, 644 responses were received from all the residential areas. For commercial, institutional and industrial water uses, one hundred (100) representative sampling were selected and the questionnaires were then administered.

2.2 Data Analysis and Results

2.2.1 Residential Users

The total volume of water used by all households divided by the total population gives the per capita water use. The result of the analysis from the distributed questionnaires showed that the residential water use in low density areas ranged between 70.25 l/c/d to 115.22 l/c/d with an average value of 92.74 l/c/d. The residential water use for medium density areas ranged from 55.02 l/c/d to 66.94 l/c/d, with an average of 61.22 l/c/d. Also the residential water use in high density areas was

between 46.07 l/c/d and 96.37 l/c/d with an average value of 71.22 l/c/d. The differences that exist in the water use rates among the study areas are as result of variation in socio economic level, standard of living, age of community, population, availability of water and level of sanitation awareness. The population of households affects total water use. The population distribution is as shown in Table 1 for the various residential areas. 142 households out of 272 sampled in medium density areas have the number of residents between 5 and 8. For the low density areas, most of the households have between 5 and 8 (i.e. about 52% of the total households sampled in this category). None of the households in the low density residential areas have its number of occupants greater than 16. Table 2 gives the detail analysis of the type of houses that exists in the study areas under each category. For

Table 1: Distribution of Residents in Households

Number of people in household	Number of Households		
	Low Density Area	Medium Density Area	High Density Area
1-4	69	61	31
5-8	96	142	83
9-12	18	30	38
13-16	3	15	19
>16	0	24	15

the densely populated area, 47% of the people live in multi-tenant buildings popularly called 'face to face', 23% in storey buildings, 20% in flats or apartments and 10% in bungalows. Bungalows type house were most common for medium populated areas, followed by flats, multi-tenant houses, and storey buildings in that order. Most of residents do not depend on direct public supply (tap water alone), they also source for water from combination of wells and boreholes. Table 3 shows that in the low and medium density areas, more households depend on a combination of taps and wells, while in the high density areas, residents depend on a combination of taps and wells, while in the high density areas, residents depend more on wells and boreholes. Size of property in the various categories of the residential areas was plotted against the total demand.

Table 2: Type of Houses in the Residential Areas

Type of Houses	Low Density Area	Medium Density Area	High Density Area	Total
Flat	85	71	38	194
Bungalow	53	99	18	170
Storey Building	38	34	43	115
Multi-tenant houses	0	68	88	156
Total	186	272	186	644

Table 3: Sources of Water Supply to the Residential Areas

Source of Water	Number of Households indicating Various Sources of Water		
	Low Density Area	Medium Density Area	High Density Area
Only Tap	27	45	20
Only Well	5	55	4
Only Borehole	19	15	32
Tap and Well	99	118	45
Tap and Borehole	22	4	16
Well and Borehole	4	30	59
Borehole, Well and Tap	10	5	10

2.2.2 Commercial, Industrial and Institutional Water Users

The daily values for all commercial, industrial and institutional facilities sampled within the metropolis were 75,535, 188,735 and 161,680 litres respectively. Tables 4 to 6 and Figures 1 to 3 shows the summary of all the commercial, institutional and industrial consumers surveyed respectively. Retail shops have the highest number

followed by the food canteens as commercial users. Other types of establishment include business centers, petrol filling stations, video clubs, etc. Out of 95 institutional consumers sampled, nursery and primary schools have the largest number and closely followed by secondary schools. Banks, ministries and parastatals have the least number. A total number of 95 industrial consumers were surveyed consisting mostly of block making industries. Others include soap making, printing, paper production, etc.

Table 4: Summary of the Commercial Consumers Surveyed

Type of Establishment	No	%
Retail Shops	49	29.17
Hotels	16	9.52
Canteens	39	23.21
Slaughter Slabs	3	1.79
Car Wash	8	4.76
Dry Cleaners	6	3.57
Cool Spots	7	4.17
Hair Dressing Saloons	20	11.90
Others	20	11.90
Total	168	100

Table 5: Summary of the Institutional Consumers Surveyed

Type of Establishment	No	%
Banks	2	2.11
Clinics	5	5.26
Hospitals	18	18.95
Nursery and Primary Schools	32	33.68
Secondary Schools	28	29.47
Post-Secondary Schools	3	3.16
Government Ministry / Parastatals	5	5.26
Others	2	2.11
Total	95	100

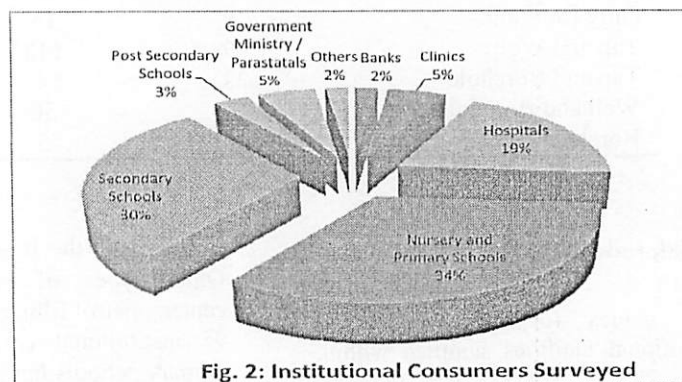
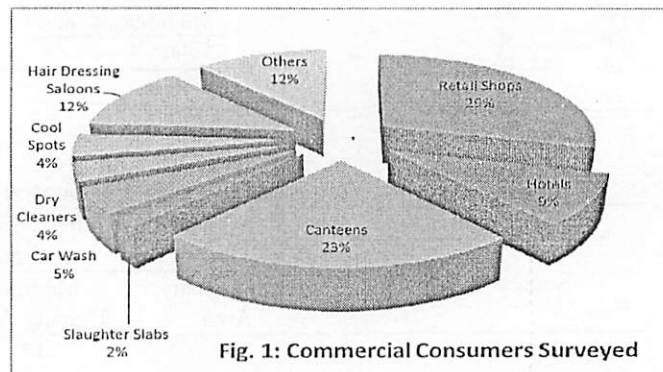
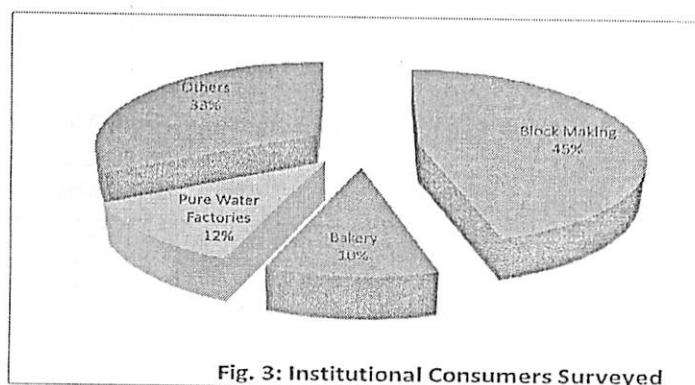


Table 6: Summary of the Industrial Consumers Surveyed

Type of Industry	No	%
Block Making	43	45.26
Bakery	10	10.53
Pure Water Factories	11	11.58
Others	31	32.63
Total	95	100

**Fig. 3: Institutional Consumers Surveyed**

The sources of water for the various commercial, institutional and industrial users surveyed are summarized in Table 7. All categories of users depend mostly on combination of tap water and wells. This is followed by the combination of

taps and boreholes. None of the commercial users sampled source for water from only borehole, while 11 industries use boreholes. Water from wells and public supplies to the industries is used variously.

Table 7: Sources of Water Supply for Commercial, Industrial and Institutional Consumers Surveyed

Source of Water	Number of Establishment		
	Commercial	Industrial	Institutional
Only Tap	13	21	33
Only Well	23	19	23
Only Borehole	0	11	1
Tap and Well	81	39	37
Tap and Borehole	39	11	1
Well and Borehole	3	1	0
Borehole, Well and Tap	1	1	0

2.3 Mathematical Modeling of Water Use

2.3.1 Hospitals

These are important and larger users of water for daily and efficient health care delivery. Their uses of water depend largely on bed spaces and number of workers employed by the hospital. This is so because patients and hospital workers need water regularly for washing, drinking, sanitation, laundry and cooking. Table 8 shows the data on number of bed spaces, the number of staff and the total water use obtained from responses to questionnaires administered to selected hospitals in Ilorin. A multiple regression equation of the form:

$$D = a + bx + cy$$

is generated in which D is the dependent variable and x and y are dependent variables. Hence for hospitals, the following multiple variable equation was obtained

$$WU = 45.93BS + 42.47HW - 109.41 \quad (R^2 = 0.955)$$

Where: WU is the total water use in the hospital (l/d)

BS is the number of bed spaces in the hospital

HW is the number of hospital workers in the hospital

2.3.2 Hotels and Guest Houses

These are also important and larger users of water, since they need to provide water for their

guests and other customers who patronize them. Water is needed for bathing, preparation of meals, general sanitation and laundry. In addition, the workers also need water since they spend appreciable time in the work place on daily basis. Water use will therefore depend largely on the number of rooms in the hotel/guest house and number of worker. Table 9 shows the information obtained on the number of rooms, number of workers and total water use for various hotels/guest houses sampled within Ilorin. The following equation has been fitted using multiple regression analysis.

$$WU = 33.39RM + 48.03WK + 729.18 \quad (R^2 = 0.686) \quad (3)$$

Where: WU is the total water use in the hotel/guest house (l/d)

RM is the number of rooms in the hotel/guest house

WK is the number of workers in the hotel /guest house

2.4 Statistical Tests

The F-test and the t-test were performed on the results in equation 2 and 3 above. The F-test is useful in checking whether a relationship exists between the dependent variable (daily volume of water use) and the independent variables (bed spaces, hotel rooms, workers, etc). The high values of R^2 indicate that the regression equations are useful in predicting water use patterns in some commercial establishments. However, the F-test was performed to determine whether the observed relationships between the dependent variables and the independent variable occur by chance. In addition, the t-statistic is used to determine whether each coefficient (or variable) is important in estimating the water use. Table 10 shows the results of the statistical tests.

Table 8: Bed Spaces, Staff Data and Total Water Use

S/No	Name of Hospital	No of Bed Space (BS)	Hospital Workers (HW)	Water Use (WU) (l/day)
1	Midland Eye Clinic	8	2	200
2	Mercy Eye Clinic	-	3	110
3	Wale Clinic	-	5	200
4	Arewa Clinic & Maternity	14	5	580
5	Gerin-Alimi Hospital	24	8	1470
6	Asa Dam Clinic	15	6	920
7	Ifedayo Clinic	18	8	1230
8	Dominion Clinic	20	8	1390
9	Ifcolu Medical Centre	24	8	1200
10	Kiddiz Medical Centre	30	7	1690
11	Cottage Medical Centre	16	4	810
12	Dayspring Hospital	10	6	520
13	Murab Hospital	20	6	1170
14	Queens Hospital	12	6	650
15	Oyin Folorunsho Hospital	15	5	700
16	Sarfam Medical Centre	9	4	510
17	Omosobi Maternity Home	23	7	1090
18	Ola-Olu Hospital	48	12	2560
19	Surulere Clinic & Maternity	20	5	1000
20	Ilorin Clinic & Maternity	36	6	1760
21	Kulende Hospital	-	11	420
22	Omoda Health Care	8	11	480

The results show that since the F-values (202.61, 13.12) are much greater than the F_{cr} (3.521, 3.682) for both hospitals and hotels/guest houses respectively, then the regression equations are useful for predicting water use. The result of the t-test for hospitals indicates that at 5% significance level the two independent variables are useful in estimating water use. In the case of hotels/guest houses only the

number of workers was found to be statistically significant in estimating water use by this category of consumers. Where there is no provision for flow meters to measure actual consumption, utility agencies can use equations similar to those in (2) and (3) above to estimate water consumption and adapt the users appropriately.

Table 9: Hotels / Guest Houses and Total Water Demand

S/No	Name of Hotels/Guest Houses	No of Rooms (RM)	No of Workers (WK)	Water Use (WU) (l/day)
1	Lucky Pat Hotel	50	10	2850
2	P & P Guest House	40	11	3480
3	Deens Hotel	35	11	2800
4	Jomar Guest House	28	4	1350
5	Geoniks Hotel	20	6	1160
6	Spring Motels	15	4	1300
7	Segnid Guest Inn	20	9	1140
8	Purple Hill Guest House	24	8	2390
9	Circular Hotel Ltd	80	10	5100
10	Prince Palace Hotel	30	6	2600
11	Henry George Guest House	20	6	3300
12	Hotel De Victor	20	6	2300
13	Ever Guest House	15	2	1700
14	Phoenix Guest House	18	3	1550
15	Nokbul Hotel	20	4	2150

Table 10: Results of F-test and t-test performed on the models

Item	Test	Parameters	Hospitals	Hotels/Guest Houses
A.	F-test	R ²	0.955	0.686
		Degree of Freedom	19	12
		Level of Significance (α)	0.05	0.05
		F _{cr}	3.521	3.682
		F-value	202.61	13.12
B.	t-test	Variables	t-values	t-values
		No. of Bed Spaces	3.438	-
		No. of Rooms	-	0.431
		No. of Workers	17.011	3.568
C.	Other Parameters	Level of Significance (α)	0.05	0.05
		Degree of Freedom	19	12
		t _{critical}	2.093	2.179

3.0 Conclusion

The study looked at water use pattern of various categories of water users. From the results and responses and comments received during field administration of questionnaires, it can be deduced that there is a general shortfall in water supply to many areas in Ilorin. Most residents were found to use between 46 and 115 litres per person per day. The high rates were common in low density areas and the low rates in medium and high density areas of the city. Moreover, public water distribution system is not adequate, because majority of consumers still source water from wells or boreholes to meet their basic needs. Some models have been generated which could be used to estimate water need for planning and operational purposes. The results of the models show that if water use by some categories of commercial consumers can be estimated knowing certain variables.

References

- Alsharif, K., Feroz, E.H., Klemer, A. and Raab, R. (2008): Governance of Water Supply Systems in Palestinian Territories: A Data development Analysis Approach to Management of Water Resources, Journal of Environmental Management, Vol. 87, pp. 80-94.
- Arbues, F., Garcia-Valinas, M.A. and Martinez-Espineira, R. (2003): Estimation of Residential Water Demand: A State-of-the-art Review, Journal of Socio-Economics, North Holland, Vol. 32, pp. 81-102.
- Bithaş, K. (2008): The Sustainable Residential Water Use: Sustainability, Efficiency and Social Equity, The European Experience, Ecological Economics, Vol. 68, pp. 221-229.

- Bouwa, H. (2000): Integrated Water Management: Emerging Issues and Challenges, Agricultural Water management, Vol. 45, No. 2, pp. 217-228.
- Davis, Y.W. (2003): Water Demand Forecast Methodology for California Water Planning Areas – Work Plan and Model Review, A final Report Submitted to California Bay-Delta Authority, California, pp 1-34
- Mohammed, A.S. (2000); Water Demand management in Egypt: Policy, Objectives and Strategy Measure, Physics and Chemistry of the Earth, Vol. 25, No. 23, pp. 243-249.
- Mulwafu, W., Chipeta, C., Ferguson, A., Nkhoma, B.G. and Chilima, G. (2003): Water Demand Management in Malawi: Problems and Prospects for its Promotion; Physics and Chemistry of the Earth, Vol. 28, pp 787-796
- Garcia, S. and Réynaud, A. (2004): Estimating the Benefits of Efficient Water Pricing in France, Resources and Energy Economics, Vol. 26, pp. 1-25.
- Gilg, A. and Barr, S. (2006): Behavioural Attitudes Towards Water Saving? Evident from a Study of Environmental Actions, Ecological Economics, No. 57, pp. 400-414.
- Gleick, P.H. (1996), Basic water requirements for human activities: Meeting basic needs, Water International, vol. 21, pp 83-92.
- Gomez-Limon, J.A. and Berbel, J. (2000): Multicriteria Analysis of Derived Water Demand Functions: Spanish case Study, Agricultural Systems, Vol. 63, pp. 49-72.
- Gumbo, B., Juizo, D. and Zaag, P. (2003): Information is a Prerequisite for Water Demand Management: Experience from Four Cities in Southern Africa, Physics and Chemistry of the Earth, Vol. 28, pp. 827-837.
- Randolph, B. and Troy, P. (2008): Attitude to Conservation and Water Consumption, Environmental Science and Policy, Vol. 11, pp. 441-455.
- Reed, B. (2005): Minimum Water Quantity Needed for Domestic Use in Emergencies, WHO Technical Notes for Emergencies, WEDC, Loughborough University, Leicestershire, UK, Technical Note No. 9, pp. 1-4.
- Renwick, M.E., and Green, R.D. (2000): Do Residential Water Demand Side Management Policies Measured Up? An Analysis of Eight California Water Agencies, Journal of Environmental Economics and Management, Vol. 40, pp. 37-55.
- Ruijs, A., Zimmermann, A. and vandenBerg, M. (2008): Demand and Distributional Effects of Water Pricing Policies, Ecological Economics, Vol. 66, pp. 506-516.
- Schleich, J and Hillenbrand, T. (2009). Determinants of Residential Water Demand in Germany, Ecological Economics, Vol. 68, No. 6, pp. 1756-1769.