# 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 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 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 |
| 8 | 96 | 142 | 83 |
| 9-12 | 18 | 30 | 38 |
| 13-16 | 3 | 15 | 19 |
| >16 | 0 | 24 | 15 |

**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 |

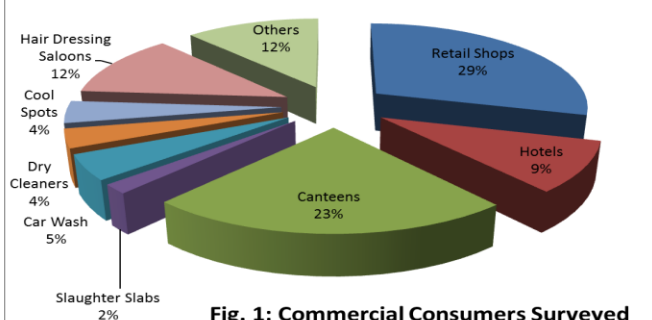


**Fig. 1: Commercial Consumers Surveyed**

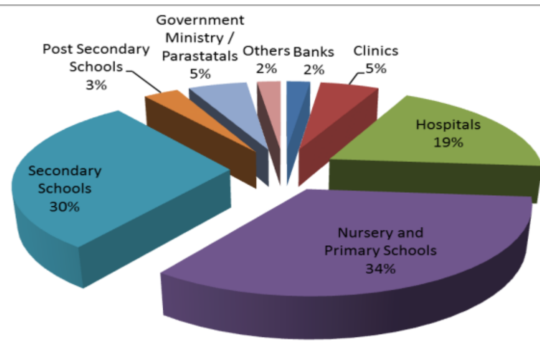


**Fig. 2: Institutional Consumers Surveyed**

**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** |

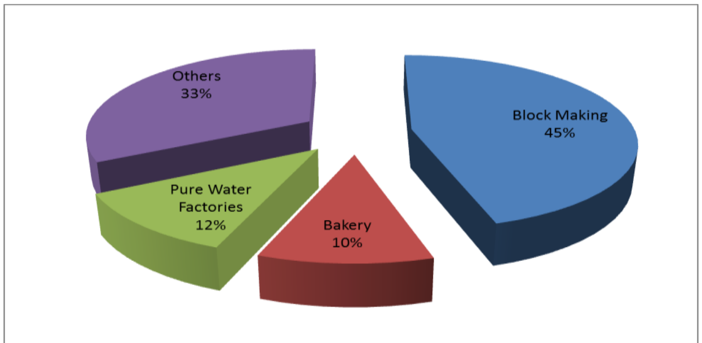

**Fig. 3: Institutional Consumers Surveyed**

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.

$WU = 33.39RM + 48.03WK + 729.18$ ($R^2 = 0.686$) (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 | Ifeolu 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 | Omosebi 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 |
|---|---|---|---|---|
| | | $R^2$ | 0.955 | 0.686 |
| | | Degree of Freedom | 19 | 12 |
| **A.** | **F-test** | Level of Significance (α) | 0.05 | 0.05 |
| | | $F_{cr}$ | 3.521 | 3.682 |
| | | F-value | 202.61 | 13.12 |
| | | **Variables** | **t-values** | **t-values** |
| **B.** | **t-test** | No. of Bed Spaces | 3.438 | - |
| | | No. of Rooms | - | 0.431 |
| | | No. of Workers | 17.011 | 3.568 |
| | | Level of Significance (α) | 0.05 | 0.05 |
| **C.** | **Other Parameters** | 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.

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