A Comparative Study of Operations and Maintenance of Iju Water Works

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Abstract: A water supply system is designed to provide potable water to its intended consumers. The design takes into account the required quantity for the intended population. A typical water supply system includes withdrawal from source, headworks, treatment plant, storage system and distribution system. The operation and maintenance of water supply systems helps it reach its serviceability limit. The study was carried out by comparing the operation and maintenance routine in Iju water supply scheme, Ota and Arakanga water supply scheme, Abeokuta, Ogun State by obtaining records of input parameter such as daily operation routine, installed capacity of the schemes, production duration, salary cost, operation and maintenance cost, chemical cost, output parameters such as volume of water produced and sold, revenue recovered, general customer care and services records. It was observed that the better performance of Abeokuta can be traced to the residence of the government in the state capital, infiltration of elites being the state capital in comparison to Ota which has more middle- and low-income earners in spite of the presence of industries based on the revenue recovery success and government subsidy. It was therefore recommended that operation and maintenance technique used in Arakanga Abeokuta be implemented in Ota, new connections be made in newly developed areas in order to increase the effectiveness of the schemes ensuring that potable and ample supply of water is obtained in these municipal cities.

Keywords: water; water supply; treatment plant.

1. Introduction
Water is essential to life. It is a substance which is composed of the chemical elements hydrogen and oxygen. Water exists in gaseous, liquid and solid states. It is vital to life, participating in virtually every process that occurs in plants and animals. Although the molecules of water are simple in structure (H₂O), the physical and chemical properties of the compound are extraordinarily complicated. Water is a colourless, tasteless, and odourless liquid at room temperature. One of its most important properties is its being a universal solvent. The universality of water as a solvent is essential to living organisms. Life is believed to have originated in the world's oceans, which are complicated solutions. Living organisms use aqueous solutions—e.g., blood and digestive juices—as mediums for carrying out biological processes [1].

However, in the most practical sense, water accessible to man is sometimes not odourless, colourless and tasteless. They contain one form of impurity or the other. The essence of this study is to ensure potable water of (good quality, reliable source, required quantity, distribution and maintenance of facilities) is obtained by everyone in this municipal city.

Water Resources as a branch of Civil Engineering is concerned with the design, construction and maintenance of structures, utilities and facilities which serves the purposes of the civil society. Hydrology is concerned with the assessment of the resources in the hydrological cycle and their management for optimum results. 96.5% of this water occurs as saline seawater and much of the remaining fresh water is incorporated into polar icecaps and glaciers. Only about 0.7% of the earth’s water exists as freshwater in lakes, rivers, shallow aquifer and in the atmosphere [2].

Laymen, unfamiliar with engineering problems often view the enormous activity in flood mitigation, irrigation, and other phases of water resources engineering with the thought that opportunities for further
work must be negligible. However, modern civilization is far more dependent on water than were the civilization in the past. Modern medical science as well as modern sanitary engineering has reduced death rates and increased life expectancy. Modern standards of personal cleanliness require vastly more water than was used centuries ago. The increasing population requires expanded acreage for agriculture, much of which must come through land drainage or irrigation. Increasing urban population require more attention to storm drainage, water supply and sewerage. Industrial progress finds increasing uses for water in process industries and for electric-power production [3].

The level of investment in water and sanitation, even though low by international standards, has increased during the 2000s. Access has also increased significantly. According to the UNICEF/WHO data, in 1980 rural sanitation coverage was estimated at 1% and reached 21% in 2008. Also, the share of Indians with access to improved sources of water has increased significantly from 72% in 1990 to 88% in 2008. At the same time, local government institutions in charge of operating and maintaining the infrastructure are seen as weak and lack the financial resources to carry out their functions. In addition, no major city in India is known to have a continuous water supply [4] and an estimated 72% of Indians still lack access to improved sanitation facilities.

At the 4th Earth watch conference on Water held 19th-23rd September, 2005 at the Lagos Airport Hotels, Ikeja, factors militating against the issues of water supply and urban sanitation in Nigeria were considered. Below are some of the factors and their solutions:

- The rapid increase in the use of plastic for packaged water and plastic as waste litter the roadsides in urban centres (with plastic recycling, reuse and recovery programmes as solution).
- Poorly constructed and poorly maintained wells and boreholes by urban residents makes the groundwater an unfit source for potable water supply (borehole/well owners should take up the responsibility of ensuring proper management and sanitary measures to prevent supply of unwholesome water).
- Borrow pit used as waste disposal and poor waste water management in urban centres are large sources of contaminants (the government together with the private sector should work together towards creating a functional waste management and treatment system).
- Direct channeling to surface drains of waste water from industries and domestic source have serious implications on the water quality and cleanliness of the environment.
- Like in most public sector managed infrastructure, water supply systems in Nigeria are experiencing management and operational problems such as neglected and leaking pipelines, inability of the Water Supply Agencies to finance the rising cost of water production and supply, or the lack of adequate water supply in most towns in the country, this evidence therefore suggesting that important source of the problem is institutional i.e. the ownership and management structures responsible for water supply systems (the NGOs should be involved in the area of monitoring the ongoing privatisation).
- Average monthly supply output from water schemes in urban centres are less than 30 litres/person/day. This was due to the fact that all aspects of urban water supply schemes are filled with serious problems ranging from the source, distribution systems, transmission systems, treatment processes and management of schemes.
- Less than 15% of all water schemes in the country where operating above 50% installed capacity.
  - Inability to finance the water supply sector and the low tariff charged.
  - Lack of accountability inherent in public sector water systems due to responsibility not clearly defined prevents them from operating in the most efficient manner.

To the last four factors, it was recommended that a transitional 10-15 years period should be initiated during which all State Water Agencies and River Basin Development Agencies will move from commercialized to privatized agencies as the Nigerian Water Supply Sector is not yet ripe for either the French Model which emphasizes franchise agreement between municipalities and the private sector nor the British which is outright privatisation of the assets and management of the water supply systems.

1.1. Study Area
This study is localised to the general operation and maintenance of Iju Water works, Ota with respect to Arakanga Water Scheme, Abeokuta Ogun State. Ado-Odo/Ota Local Government Area is one of the 19 Local Governments and the third largest Local Government Area of Ogun State. The capital of Ado-Odo/Ota Local Government is Ota at Latitude 6°41'00''N and longitude 3°41'00''E which borders on by the metropolitan Lagos to the south and Ifo Local Government to the west. Ota is an industrialised town. It has an area of 1,460km² and a population of 526,565 at the 2006 census.

Abeokuta, the capital of Ogun state, situated in south-west Nigeria covers an approximate area of about 40.63km² of the South West. It lies between latitude (7°9'0.000"N) and longitude (3°2'1"E). Abeokuta is a historic Yoruba town, formed by the Egbas in 1830. The town has become increasingly cosmopolitan as a result of the elevation in status of Abeokuta to state capital in 1976. The town is within the rainforest zone of Nigeria, its geographical location making it easily accessible to Lagos, the commercial capital of Nigeria, industrial state and main seaport.

2. Materials and methods

This study was conducted adopting survey method of the data collection, specifically to determine the supply capacity, operation and maintenance of the supply system of the water work.

The sampling techniques followed were

1. Visit to the Iju Waterworks and Arakanga Water Supply Scheme.
2. Meeting with the Member-in- charge/ plant Manager to obtain the operation and maintenance system of the schemes which will follow a pattern of interview based on questions arising from the basic requirement of operation and maintenance.
3. Visit the operation.
4. Taking of Photographs of relevant component.
5. Obtain copy of the Design Report (the design and installed capacity of the scheme).
6. Obtain copy of the Maintenance Report.

Survey and Data Collection Instrument were digital Camera, stationery Materials- writing pad and pen, safety boot, safety helmet. Data collation was carried out with the use of computer and computer applications such as Microsoft Excel (2007) and statistical package for social sciences (SPSS) to obtain, tables, charts and graphs of the data content. The data were prorated to give results for the effective operation and maintenance of the scheme.

3. Results and discussion

This section contains the basic parameters for the assessment of the operation and maintenance of Iju Waterworks, Ota by comparing the parameters of the Ota scheme with the Abeokuta Scheme (Arakanga New Scheme)

3.1. Iju Waterworks key activities of Operation and Maintenance (Result of verbal interview)

Name of Corporation and Location: Iju Waterworks (Otta Main Scheme), Arobieye junction, Otta Ogun State.

Year of Establishment: 1993

Source of Revenue: Ogun State Government and self-sustenance (water sales e.g. 20 naira per 200litres (10L/₦), billing by metering by assumption of 6 heads in a family flat rate of 500 naira per month).

Raw Water Source: Iju River

Consumers: Industries, Bells University, Commercial Institutions, Iju, Sango, Otta via Oju-ore, Iyana Iyesi.

Shifting Operations: 7.00 am-2.00 pm, 2.00 pm-6.00 pm, 6.00 pm- 6.00 am on a regular schedule; only single shift is operational at the moment because of shortage in staff.

Production Duration: 6-10 hours daily.

Source of Power: PHCN power supply, ongoing construction of black oil generating plant project for substitute power.

Pumps: 1 (No) 37kW low lift pump, 2(No) 75kW high lift Pump for distribution.

Size of Clearwater Tank: 1000m³ (1ML)
Size of tank at booster station: 700m³ (0.7 ML)
Staffing: Mechanical, Electrical and Quality control
Preventive Maintenance Practice:
• Oiling of pump every three-month based on the rate of production.
• Tightening of all bolts and nuts.
• Washing of treatment plant every last Tuesday of the month to remove debris, algae and sludge.

3.2. Arakanga Waterworks key activities of Operation and Maintenance (Result of verbal interview with Mr. Wumi Aboyade)

Name of Corporation and Location: Arakanga Waterworks (New Scheme), along Iberkodo, Abeokuta Ogun State.
Year of Establishment: November 9th, 1988
Source of Revenue: Ogun State Government and self-sustenance (water sales e.g. 20 naira per 200 litres, billing by metering by assumption of 6 heads in a family flat rate of 500 naira per month).
Raw Water Source: River Ogun
Consumers: Abeokuta metropolis
Shifting Operations: Morning and Night shifts.
Pumping Capacity: 82 MLD
Production Duration: 10-24 hrs daily.
Source of Power: PHCN power supply, ongoing construction of black oil generating plant project for substitute power.
Pumps: 6 (No) 300kW low lift pump, 5(No) 1100kW high lift Pump for distribution.
Size of Clearwater Tank: 6,830 m³ (6.83 ML)
Distribution Reservoir: Asaran Hill with 160 metres elevation
Staffing: Mechanical, Electrical and Quality control personnel.

3.3. Comparison between Iju Waterworks and Arakanga Waterworks’ Key Activities

The comparison between the Iju waterworks and Arakanga waterworks are presented in Table 1.
### Table 1: Comparison between Iju and Arakanga Waterworks

| Parameters                     | Iju Waterworks                     | Arakanga Main Scheme             |
|-------------------------------|-----------------------------------|----------------------------------|
| Year of establishment         | 1993                              | 1988                             |
| Water source                  | Iju river                         | Ogun river                       |
| Source of Revenue             | Billing and Government subsidy     | Billing and Government subsidy    |
| Power Source                  | PHCN                              | PHCN                             |
| Pump capacity                 | 1no. low-lift pump (37kW), 2 no. High-lift pump (75kW) | 6 no. low-lift pump (300kW), 5 no. high-lift pump 1100kW |
| Capacity of the scheme        | -                                 | 82 MLD                           |
| Size of Clearwater tank       | 1,000 Cum (1ML)                    | 6,830 Cum (6.83 ML)              |
| Reservoir                     | Booster tank is 700 Cum (0.7 ML)   | Distribution reservoir located at Asaran hill of elevation 160m is 22,500 Cum (22.5 ML) |
| Staffing                      | Mechanical, Electrical and Quality Control personnel | Mechanical, Electrical and Quality Control personnel |

### Water Treatment Plant

| Similar Operations            | Aeration                          | Aeration                          |
| Pressure Control              | Non returning valve               | Soil water tank                   |
| Desludging valve              | Desludging valve                  | Day and Night Shift operation     |
| Day and Night Shift operation |                                   |                                   |
| Variation in Operation        | Aluminium sulphate is added in solid form to the sedimentation tank | Aluminium sulphate is prepared in a separation tank and dissolution tank before use. Organised routine of chemical preparation |
| High Test Hypochlorate is used for chlorination | Chlorine gas is used |
| Absence of flow meter to measure the inflow rate | Absence of flow meter to measure the inflow rate |
| Maintenance of pumps          | Oiled once every three-month based on the rate of production | Readings are taken off the control panel and the oil level in the pump is checked daily. |

### 3.4. Input Cost for The Year 2010

For the measurement of the efficiency of the operation of a water supply system, the principle: efficiency is a function of input and output can be applied.
The input cost for the running of both the Iju waterworks and Arakanga waterworks comprises:

- The cost of labour (Salary) (Table 2),
- The cost of operation and maintenance (Figure 1) and
- The cost of chemicals (Figure 2).

Table 2 shows the cost of salary paid to both the workers in Ota and Abeokuta. It is observed that there is a great margin between the salaries of the workers in Ota and Abeokuta due to the high staff strength in Abeokuta which is about four times that of Ota. Incentives in the form of bonuses (a certain percentage of the revenue recovered) given for revenue recovery by staff could also be the reason for the high salary and the variation in the amount paid every month.

### Table 2: Comparison between Iju and Arakanga Key Activities

| MONTH | SALARY (OTA) ₦ | SALARY (ABEOKUTA) ₦ | STAFF STRENGTH (OTTA) | STAFF STRENGTH (ABEOKUTA) | MULTIPLIER |
|-------|----------------|-------------------|----------------------|---------------------------|------------|
| JAN   | 1,014,125      | 4,614,834         | 54                   | 233                       | 4          |
| FEB   | 1,206,181      | 4,307,088         | 57                   | 233                       | 4          |
| MARCH | 1,278,836      | 4,826,769         | 64                   | 233                       | 4          |
| APRIL | 1,243,732      | 6,170,947         | 64                   | 234                       | 4          |
| MAY   | 1,681,709      | 6,912,570         | 66                   | 238                       | 4          |
| JUNE  | 1,583,932      | 6,223,853         | 66                   | 238                       | 4          |
| JULY  | 1,325,011      | 5,871,975         | 54                   | 233                       | 4          |
| AUG   | 1,257,186      | 5,082,966         | 57                   | 233                       | 4          |
| SEPT  | 1,325,783      | 5,137,243         | 64                   | 233                       | 4          |
| OCT   | 1,313,220      | 4,353,179         | 64                   | 234                       | 4          |
| NOV   | 1,298,997      | 5,100,439         | 66                   | 238                       | 4          |
| DEC   | 1,237,582      | 4,990,740         | 66                   | 238                       | 4          |

Figure 1. The cost of operation and maintenance of Ota and Abeokuta
3.5. Output Cost for The Year 2010

The input cost: cost of operation and maintenance, salary and cost of chemicals is expended in order to get an output. The assessment of operation and maintenance of Ota in comparison with Abeokuta’s output cost.

Output costs include:

- The volume of water produced and sold (Tables 3 and 4),
- The percentage of non-revenue water based on billing and collection (Figures 3 and 4),
- Percentage response to leaks/bursts repair, customer complaints.

Table 3. The volume of water produced, volume of water sold and % of water not sold in Ota

| Month (OTA) | Volume of Water Produced (cum) | Volume of Water Sold (Cum) | Non Revenue Water(%) |
|-------------|--------------------------------|----------------------------|----------------------|
| JAN         | 29,656                         | 13,345                     | 55%                  |
| FEB         | 14,784                         | 6,653                      | 55%                  |
| MARCH       | 37,956                         | 17,080                     | 55%                  |
| APRIL       | 38,551                         | 17,348                     | 55%                  |
| MAY         | 15,400                         | 6,930                      | 55%                  |
| JUNE        | 37,135                         | 16,711                     | 55%                  |
| JULY        | 22,066                         | 17,652                     | 20%                  |
| AUG         | 30,233                         | 24,187                     | 20%                  |
| SEPT        | 0                              |                            |                      |
| OCT         | 0                              |                            |                      |
| NOV         | 0                              |                            |                      |
| DEC         | 0                              |                            |                      |
Table 4. The volume of water produced, volume of water sold and % of water not sold in Abeokuta

| Month (ABEOKUTA) | Volume of Water Produced (cum) | Volume of Water Sold (Cum) | Non Revenue Water(%) | Revenue |
|------------------|-------------------------------|---------------------------|----------------------|---------|
| JAN              | 1,218,832                     | 633,793                   | 48%                  |         |
| FEB              | 722,820                       | 375,866                   | 48%                  |         |
| MARCH            | 791,893                       | 411,784                   | 48%                  |         |
| APRIL            | 1,245,640                     | 594,317                   | 52%                  |         |
| MAY              | 1,446,470                     | 594,317                   | 59%                  |         |
| JUNE             | 1,378,260                     | 594,317                   | 57%                  |         |
| JULY             | 1,511,352                     | 747,312                   | 51%                  |         |
| AUG              | 1,638,932                     |                            | 100%                 |         |
| SEPT             | 923,245                       |                            | 100%                 |         |
| OCT              | 0                             |                            | 0                    |         |
| NOV              | 0                             |                            | 0                    |         |
| DEC              | 0                             |                            | 0                    |         |

Figure 3. The variation in the billing and collection of revenue in Ota
3.6. Records of Equipment and Machinery (logbook and history book: services, lubrication, replacement of parts, Operating hours)

A logbook was created to record the operating hours of the High lift pumps, Low lift pump and the Power house. These operating hours is determined by the duration of power supply. Records are kept of the power supply and power failure in accordance with their effect on production. When the level of water in the Clear well tank is low, one high lift pump is in use. While two is in operation in cases of high level of water in the clear well tank.

4. Conclusion

From the results generated, variation occurs due to the size of the scheme, quality of people working in the cities (Ota low/middle class and Abeokuta middle/ high class), funding capacity due to the residence of government in Abeokuta affects the efficiency of the scheme. The quality of water produced in the two waterworks is ensured, however due to factors such as high percentage of non-revenue water, percentage of revenue not recovered, adequate and continuous supply of water is not guaranteed.

Furthermore, comparison of the two water supply systems has been made based on the assessment of the operation routine and maintenance technique in Iju and Arakanga relatively (Objectives of the study) been achieved.

In conclusion, operation and maintenance technique in Arakanga waterworks (which should still be improved upon) can be implemented in Iju waterworks to provide adequate and continuous supply of potable water to the intended consumers and this will also lead to the increase in income for the government.

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