STUDY OF WATER SUPPLY SYSTEM TO SOME CITY

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ABSTRACT

A water supply system is an essential urban infrastructure that ensures the continuous availability of safe and potable water to meet domestic, commercial, industrial, and public needs. This study focuses on the planning, design, and functioning of a city water supply system, including sources of water, treatment processes, storage, and distribution networks. The primary objective is to analyze how water is collected from sources such as rivers, lakes, and groundwater, treated to meet quality standards, and efficiently distributed to consumers.

The study also examines key components such as intake structures, pumping systems, water treatment plants, service reservoirs, and pipeline networks. Factors influencing water demand, population growth, and system design are considered to ensure sustainability and reliability. Additionally, challenges such as water losses, contamination risks, and supply management are discussed along with possible improvements.

Overall, this study highlights the importance of an efficient and well-maintained water supply system in promoting public health, economic development, and environmental sustainability in urban areas. The system begins with the identification of reliable water sources such as rivers, lakes, reservoirs, or groundwater, depending on availability and quality. Water is collected through intake structures and conveyed to treatment plants, where it undergoes various processes like screening, sedimentation, filtration, and disinfection to remove impurities and make it safe for consumption. After treatment, water is stored in clear water reservoirs and service reservoirs to maintain a continuous supply and to balance fluctuations in demand. The distribution system, consisting of pipelines, pumps, and valves, delivers water to households, industries, and public facilities with adequate pressure. The design of a water supply system depends on factors such as population growth, per capita demand, climatic conditions, and topography of the area. Proper planning ensures efficiency, reliability, and sustainability while minimizing losses due to leakage and wastage. Regular maintenance, monitoring of water quality, and adoption of modern technologies like smart metering and leak detection systems further improve system performance.

1. INTRODUCTION

Water is one of life's most basic needs and apparently, access to safe water has become a primary concern to the rural communities and general public at large. A lack of access to water affects agricultural productivity, food security and people's livelihoods (Akuoko-Asibey, 2007).

Globally, millions of people in developing countries face daily problems in obtaining water for domestic purposes (Steering, July 2009).

Rural Africans have the lowest level of access to clean water and sanitation facilities compared to other developing areas of the world (UNESCO-WWAP, 2003).

Projections from Uganda Bureau of Statistics indicate a population of 37.73 million as of June 2017 with 28.6 million (76%) living in rural areas. (MWE, 2017). In addition, the majority of the poor people reside in the rural areas of the country. The provision of rural water supply covers communities or villages (at the level of Local Council 1 (LC1)) with scattered population in settlements up to 1,500 people, and Rural Growth Centers (RGCs) with populations between 1,500 and 5,000. With an increasing population, there is a high demand for water in urban, semi urban and rural areas in Uganda.

The Government of Uganda (GoU) through the Ministry of Water and Environment has also initiated Water and Sanitation Development Facilities (WSDF) as a mechanism for services delivery and funding water and sanitation facilities in small towns (STs) and Rural Growth Centres (RGCs) in Uganda.

The main technology options being used for water supply improvements in rural areas include deep boreholes (42%), shallow wells14 (25%), protected springs (21%), public stand posts (6%), yard taps for public use (6%) and kiosks (1%) and rainwater harvest tanks (1%). This implies that the rural population is predominantly served by the deep boreholes technology. (MWE, 2017)

PROBLEM STATEMENT

During the peak hours (i.e.7:00am and 7:00pm), there is congestion at few improved water sources evidenced by the long queues at the water points. The distances to the improved water sources are also long and about 2km.This has led to problems like late reporting to school by school children and delayed housework by women. The lack of a piped water system has further constrained the development of Ibrahimpatnam and also lagged the sanitation of Ibrahimpatnam rural area**.**

OBJECTIVES

1. To identify the possible water sources
2. To determine the water demand in Ibrahimpatnam community.
3. To assess the physical, chemical and micro biological water parameters
4. To design the water supply system components i.e. pipe network, transmission and distribution system and sizing the storage reservoir.
5. To estimate the project costs

2. LITERATURE REVIEW

Water is a resource that has been used since the existence of mankind. Water resources are those sources of water that are useful or have a potential use. Water is mainly used for agricultural, household, industrial recreational and environmental activities.

Most of the uses of water require fresh water but 97% of the earth's water is salty. The remaining 3% of fresh water is mainly found as groundwater, with only a small percentage available above ground or in the air.

Due to the various uses of water in the daily lives of people and industries, water is becoming a scarce resource and needs to be adequately managed in order to meet the daily demands.

Water stress has become a key issue in most parts of the world. Water stress is the situation whereby there is not enough safe water for all the uses.

The most cause of water stress is population growth, expansion of business activity, rapid urbanization, climate change, and depletion of aquifers.

Water sources can be broadly divided into

- Surface water sources
- Groundwater sources
- Rainfall water.

WATER DEMAND

A water supply scheme will almost without exception cater for water demand, which will be increasing with the years to come. When designing a scheme, a decision has to be taken regarding the time in the future, for which the various components of the scheme are to be designed.

To calculate the water demand for a water supply scheme, it is necessary to do the following:

Determine the numbers of consumers falling within the different consumer categories at various stages of the design period Determine the average day unit water demand figures for the various consumer categories concerned.

There are different types of "*water demand*". These include domestic demand, institutional demand (educational institutions, health institutions etc), commercial demand (shops, workshops, restaurants, bars, hotels, banks etc), industrial demand, other demands (e.g., irrigation, firefighting, livestock demand, losses/unaccounted-for-water and internal water works demand). For water supply, the average daily per capita consumption (ADPCC) is defined as where *ADPCC* = Average daily per capita consumption

TAC = Total annual consumption

P = Design population for the area to be served

n = No of days in a year (365days)

WATER QUALITY TESTS

The first and most important aspect in water supply system design is the quality of the water for human consumption (drinking water)

The quality of water provided by a municipal water system is based on three distinct characteristics, each of which may independently govern the desirable portability of the water. These characteristics are:

- **Physical quality of water :** The physical quality of water is the appearance of the water to the consumer. Physical quality includes the clearness of the water, taste, odor, and temperature.
- **Bacterial quality of water:** The most important quality of water is that of bacteria content. In the early 20th century, disease outbreaks from water and food-borne bacteria were common throughout the world.

Water chemistry

Water is an excellent solvent, so it is not surprising that it picks up other chemicals. During this cycle of water movement, water picks up many solid and gaseous components. As the raindrops fall to the earth, they absorb gases. Most gases within the atmosphere are carbon, sulphur, and nitrogen compounds. The raindrops may also pick up particulate materials in the atmosphere. Many of the particulates are soluble in water and will dissolve within the raindrop.

STORAGE

The purpose of storing water in the distribution system is mainly twofold:

- Balancing of variations in water demand during the day; and
- Emergency storage to ensure supply during break-downs or for fire-fighting.

The balancing storage requirement in a water supply system is caused by the cyclical variations in water demand over a period of time. In ordinary water supply systems, the usual period considered is one day. If there is no facility for storing water for balancing purposes, the water source, raw water transmission main, treatment plant and treated water transmission main would all have to be designed to follow all fluctuations in water demand and this is generally not economical.

PUMPING

Pumps are hydraulic machines which convert mechanical energy (imparted by rotation) into water energy used in lifting (pumping) water to higher elevations.

The mechanical energy is provided by electrical power (motor) or diesel, gas or steam prime movers using either vertical or horizontal spindles. There are two main pump types used in Uganda as outlined below

- **Rotodynamic Pumps**
- **Centrifugal Pumps**

TRANSMISSION AND DISTRIBUTION

- The purpose of a transmission and distribution system of a water supply scheme is to deliver the right quantity and quality of water conveniently to the demand areas.
- The delivery system is classified into two: the transmission main and the distribution. Transmission mains convey water from the source, treatment, or storage facilities to the distribution system normally via a storage reservoir.
- There maybe a few service connections on the transmission main, but the purpose of this larger diameter pipe is to deliver water to the distribution mains where most of the service connections are. Distribution mains deliver water to individual customer service lines and provide water for fire protection through fire hydrants, if applicable. The distribution mains normally deliver water from a storage reservoir to the consumers.
- The extend and routing of the transmission and distribution network depends largely on the location and characteristics of the demand areas to be served, the topography of the service area and the source of water, the quantities of water to be transmitted and the available infrastructure in the area such as roads, underground facilities and infrastructures etc.
- The purpose of a water delivery system is to transport potable water from a water treatment facility to residential consumers, for use as drinking water, water for cooking, water for sanitary conditions, and other water use in a domestic environment. Water supply also is essential for business and industry to operate in an environment.

Filtration plants

- Slow Sand Filters : Slow sand filtration plant is most widely used in rural water supply schemes and is an effective, low cost system of water treatment if operated and managed correctly. A slow sand filter consists of an box about 3.0 meter deep rectangular or circular in shape and made of concrete or masonry The box contains supernatant water layer, a bed of filter media, an under drainage system and a set of control valves and appurtenances. It is normally one component in a treatment process which may involve preliminary settlement of solids and / or roughing filters and post chlorination.
- **Rapid Sand Filters:** The pre-treatment units which form essential parts of a Rapid sand filtration unit and include:
    - Aeration /Pre-sedimentation (optional),
    - Coagulation and flocculation with rapid mixing facilities
    - Sedimentation unit
    - Filtration unit

Chlorination

The primary objectives of the chlorination process are disinfection, taste and odour control in the system, preventing the growth of algae and other microorganisms that might interfere with coagulation and flocculation, keeping filter media free of slime growths and mud balls and preventing possible built up of anaerobic bacteria in the filter media, destroying hydrogen sulphide and controlling sulphurous taste and odour in the finished water, removing iron and manganese, bleaching of organic colour.

Ultra Violet Disinfection

UV irradiation and membrane processes are potentially suitable alternatives to chemical disinfection. UV is capable of inactivating bacteria and viruses, and possibly protozoan parasites. A range of pressure-driven membrane processes – microfiltration, ultra-filtration, Nano-filtration and reverse osmosis in order of decreasing pore size – are also capable of disinfection as well as removal of chemical contaminants, depending on pore size. The use of membrane processes would avoid the formation of disinfection by-products and would reduce the concentrations of other undesirable chemicals, giving a net benefit in terms of toxicological issues.

Ozonation

Ozone is very strong oxidiser and powerful disinfecting property .Avery small concentration of ozone in water makes it free from bacteria, virus and pathogen much faster and with lesser concentration in a most effective manner.

The major elements of an ozonisation system are:

- Air preparation of oxygen feed
- Electrical power supply
- Ozone generation –usually using a corona discharge cell consisting of two electrodes
- Ozone context chamber, and
- Ozone exhausts gas destruction.

DESIGN OF THE SYSTEM COMPONENTS

SPRING BOX DESIGN

An appropriate volume for the catchment box that will collect water from any of the selected spring was calculated using the equation:

$$\boldsymbol{spring\ box\ capacity = length \times width \times height.}$$

OPERATION AND MAINTENANCE OF THE SYSTEM

This Chapter presents the general concepts and practices that shall be adopted for effective Operation and Maintenance (O&M) of the Ibrahimpatnam Rural Growth water supply system.

Operation refers to the procedures and activities involved in the actual delivery of services, for instance pumping, treatment, transmission and distribution of drinking water.

Maintenance refers to the activities aimed at keeping existing facilities (physical assets) in serviceable condition, for instance painting of steel reservoirs, and repair of leaking pipes and worn out pumps.

The aims for doing the O & M for Ibrahimpatnam water supply system were:

- The useful life of the water supply facilities needs to be extended and their service quality enhanced;
- The health of the population must be maintained;
- The quality of the environment must be preserved and protected.

The consequences if O&M is not put into consideration:

- Intermittent water supply due to wastage and depletion;
- Poor water quality due to inadequate treatment and contamination;
- Deterioration of pipes, equipment, and service;
- Increased cost of maintenance; and
- Failure to secure consumers' acceptance when tariff increases are needed to sustain viability.

Maintenance of the Ibrahimpatnam water supply system is essential in preventing component failure extending the useful life of the system, and minimizing disruptions in services.

Maintenance of the Ibrahimpatnam supply system shall involve the following:

- Quick repair/replacement of any failed component;

- Up-to-date training of maintenance personnel;
- Adequate inventory of parts and tools needed for repairs;
- Efficient mobilization practices in emergencies; and
- Valve exercising (single most important form of preventive maintenance for reliability of service).

Preventive maintenance mechanisms

Preventive or routine maintenance shall involve doing tasks and activities according to pre-established schedules to ensure the quality and reliability of operating facilities. It is based on rational considerations such as the manufacturer's recommendations for servicing equipment, industry standards and practices (which are based on collective experience), durability, and reliability of the different equipment and their parts and components. Once established, these schedules need to be kept and the results recorded.

Water quality maintenance mechanism

The sole product of the Utility is water and it is mandatory for this product to meet at least the minimum standards specified by the WHO. Periodical sampling of water in the distribution network shall be done. Should a sample test be positive for coli forms, the utility must immediately have a re-sampling done and, without waiting for the results, take the actions needed to determine the possible source of contamination in order to eliminate the cause. Where the sampling method indicates that customers are at risk of using unsafe water, measures must be taken to warn customers to take the necessary precautionary measures, such as boiling their drinking water before using, until there is assurance that the risk has been eliminated.

In case of a second positive testing, suspension of operations shall be done until the problem is solved, and if this is not possible, it should reinforce its advisory to all customers to boil their drinking water until they receive notice that the problem is solved.

As part from routine water quality maintenance procedures, readings of chlorine residuals at different distribution points should be measured on a daily basis, take using a chlorine comparator.

Field tools

The Utility should have all the necessary and proper field tools for operational and maintenance work. The cost of these tools should be considered an investment that will improve maintenance work and minimize downtime.

Every SSWP must have the following maintenance tools:

Ratchet threader,Mattock (Piko) and Shovels, Adjustable wrenches, Crowbar, Pipe wrenches, Screwdrivers, Pipe threade, Pliers, Pipe cutter, Open Wrenches, Shovels, Saws and hammers Crowbars, Bench Vise

Other operational considerations

1. Monitoring

Operators must monitor readings on gauges and respond to alarms and warning signals. Failure to heed these could result in otherwise minor problems escalating into major problems. Operators must be trained to respond instantly to emergencies, and should be given the means to communicate without delay, so they can call out repairs and inform supervisory personnel. Whenever practical, well output and discharge pressures ideally should be recorded daily. If a flow meter is not available, the method given in Chapter……. can be used to measure flows from the well.

2. **Emergency Provisions**

To minimize the failure of operations during emergencies, the following shall be observed:

- Reservoirs should never go below half full before the pumps are restarted. If the operator knows the schedule of a power outage, he must ensure that the reservoir is full by the time the power is out. For power outages or calamity repairs that could last for more than a day, the operator should limit or ration the supply of water by valve throttling.

- Fuel (if used by the system) should always be on stock for at least 2 days of operational needs.
- The Utility should have an Emergency Plan, clearly designating the emergency team members, their specific functions, and a backup office or meeting place.
- The Utility should have the contact numbers of those who can assist during emergencies (nearby utilities, private deep well owners, well drillers, pump suppliers, water tankers, treatment equipment suppliers, power suppliers, government agencies, etc). The personnel designated to respond to emergencies should have these numbers.
- After a calamity, the operator must conduct a field survey to determine damaged facilities and the extent of leakage, and to conduct emergency repairs.

Records and reports

For the O&M function, the following records are particularly important and, as a minimum, shall be kept and available:

- All pamphlets/manuals of pumping equipment, including pump curves;
- As-built plans of the system or plans and engineering drawings;
- Capital expenditure disbursements;
- Water meter data such as type, when installed, and serial number.

CONCLUSIONS

Regardless of the many challenges and setbacks encountered mainly financial, all the project objectives were achieved which were; To identify the possible water sources, To determine the water demand in Ibrahimpatnam community, To assess the physical, chemical and micro biological water parametersand To design the water supply system components i.e. pipe network, transmission and distribution system and sizing the storage reservoir.
Two water sources were identified which were Scoul spring and Katumba spring. Scoul spring was chosen for our design since it was found to be adequate in terms of yield, quality and reliability. The water demand was found to be 516.010 and 307.761 cubic metres per day in the ultimate year and future years respectively.
The water quality from the chosen Scoul spring was in line with the Uganda standards for drinking water apart from turbidity and colour.
The water supply system component design had a storage volume of 100 and 200 cubic metres in the future and ultimate years respectively, the required pump transmission capacity was 1.16 litres per second and the pipe network for both distribution and transmission was composed of UPVC and HDPE pipes of diameters 160 mm, 110mm, 90mm and 40mm.
Finally the project cost estimate was found to be 1,202,916,000 UGX

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