Water auditing – tracking unaccounted-for water in Delhi, India

Harpreet Singh Kandra, Rakesh K. Johri and Amit Kapur

Unaccounted-for water losses average approximately 30 per cent of supply in developing country cities. The methods of water auditing described here can identify where losses are occurring.

Studies reveal that some 30 countries are currently water stressed (defined as having 1000–1600 cubic metres per capita per year) and, of these, 20 are absolutely water scarce (having annual internal renewable water resources of less than 1000 cubic metres per capita per year). By 2020, the number of water-scarce countries is projected to increase to 35. Wasted water is a problem experienced in many areas of today's water industry, where pressures to provide services to more people are accompanied by depleting resources. Water auditing is the first step in discovering water losses and determining the system's conservation needs.

Water demand vs availability in Delhi

Delhi presents an ideal case to study the issues facing a rapidly growing metropolis of a developing country. The metropolitan area of Delhi is currently under stress because of the need to provide basic urban services to over 15 million people within its area of 1485 square kilometres. An envisaged per capita water requirement of about 225 litres per day, coupled with a modest estimate of 15 per cent transmission losses when compared to the production of 2950 MLD (million litres per day) shows a deficit of around 900 MLD. The deteriorating quality of surface water and groundwater resources poses an equal challenge for the urban managers.

Unaccounted-for water (UFW)

In an era when many cities of the world are facing acute water shortages with high water losses (see Figure 1), the different components that make up UFW should be monitored, and measures should be taken to rectify matters. Auditing water at different stages in its cycle of conveyance, production, distribution and usage is an effective approach towards finding out what to mend and how to mend it.

Water losses in the main supply lines and water supply distribution system are due to:

- inadequacies such as poorly connected joints, uneven settling of pipe lengths, over-designed pipe sections and poor monitoring systems
- ill-functioning of meters and
- illegal thefts or connections.

Some unmetered water is authorized, for example, water used for fire fighting, the flushing of mains, process water for water treatment, landscaping and consumption by economically weaker sections. Some losses occur beyond the consumer meter, and since the water is lost but paid for, the consumption may be considered as wasteful, but not as a part of UFW.

Water audits for urban supply

A water audit is a thorough examination of a water system's records and field control equipment and it helps account for all the water conveyed through a water system. The methodology involves doing a mass balance of water usage wherein the inputs to a system are compared with the

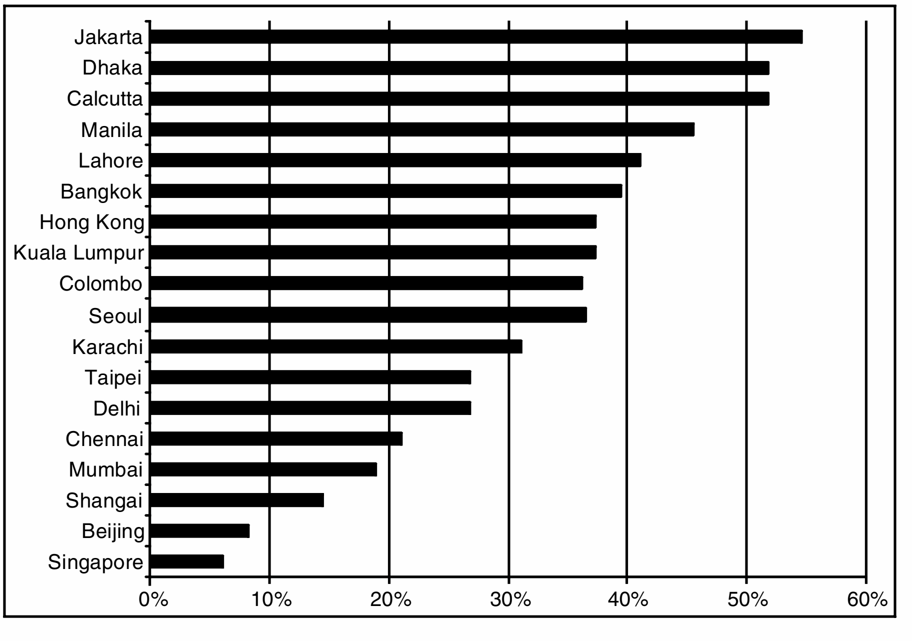


Figure 1 Unaccounted-for water in cities of the world (cities with fewer than 150 000 connections)[1]

Monitoring for losses may be targeted at any of the different stages between raw water source and a treatment facility (pictured above), within the treatment facility or in the water distribution system

Problems arose from a lack of adequate and safe working locations to measure flow

aggregate of consumption and outputs to assess the difference, which is the lost or unaccounted-for water. Such an accounting technique can be applied to the following different levels, depending on the objectives of the audit.

Municipal systems/ local public utilities. This can be done for the different stages of water flow between raw water source and a treatment facility, within the treatment facility and/or in the water distribution system. This can be undertaken for systems under pressure as well as under gravity.

Industrial process operations. Water auditing for industrial operations can be taken up as an individual activity or as part of a comprehensive environmental audit that may also look at other environmental aspects related to resource pollution.

Residential audits. These examine how much water a consumer uses. This involves an examination of the patterns in which water is used and thorough inspection and testing of all water-using devices to determine where savings may occur.

The water audit study should begin with a clear vision of the scope and objectives of the study. This becomes all the more necessary as there are different types of losses at the various stages of the water distribution cycle which all add up to the overall UFW losses. The selection of the study area is usually guided by factors such as the age of the water mains, the history of leakages, water pressure in the network, water quality and so on.

Water auditing in Okhla Water Works: a case study

The Okhla Water Works, Delhi, is a water treatment plant originally commissioned in 1952–3 with a capacity of 36 MLD and currently running at rated capacity of 81 MLD. The waterworks receives supplies of both raw water and treated water. The raw water at the plant comes from two series of Ranney wells (named after their inventor, Leo Ranney, they have horizontal 'feeder' wells radiating from the bottom of the well). The other source of water to the plant is the Bhagirathi Water Treatment Plant that supplies treated water. The distribution area under Okhla Water Works includes different areas of South Delhi.

The basic aim of this pilot study was to assess the transmission losses in the rising mains feeding the Okhla water works and prepare a guideline manual for water auditing highlighting challenges facing the study. The study also briefly aimed at estimating pump reliability vis-à-vis operating efficiency based on the available information on pump operations. The approach adopted was:

Collection of preliminary information through visits to the Ranney wells and pump houses on the network and tracing each rising main from the Ranney wells to the Okhla water works. Sketches with network details like pipe sizes and specifications were prepared. Based on these reconnaissance surveys, locations for flow measurements were also identified, keeping in mind the accessibility of pipes for measurement.

Flow measurement. Of the available measurement techniques (e.g. velocity area or electro-magnetic methods, venturi meters, orifice plates, flow meters, domestic water meters, constant-rate injection method and bucket and stopwatch estimations) flow meters were preferred for the study since it was to be carried out mainly on pipe networks.

Compilation of results. Information such as flow velocity, instantaneous discharge as measured between two sections (in million litres), totalled flow and hourly flows (half- and one-hourly flows) were recorded for all locations on a worksheet similar to an accounting spreadsheet. This made computations and analysis clear and simple so as to balance water produced with water supplied by each source. Significant findings included:

- Different studies indicated that the discharge from Ranney wells is not very uniform and varies with the type of pump in operation and the level of water in the Ranney wells. Conflicting values of discharges were obtained from the same Ranney well with different pumps in operation. Efficiencies of pumps as calculated by comparing the measured pump discharge with the rated pump discharge show that average pump efficiencies range between 65 and 80 per cent.

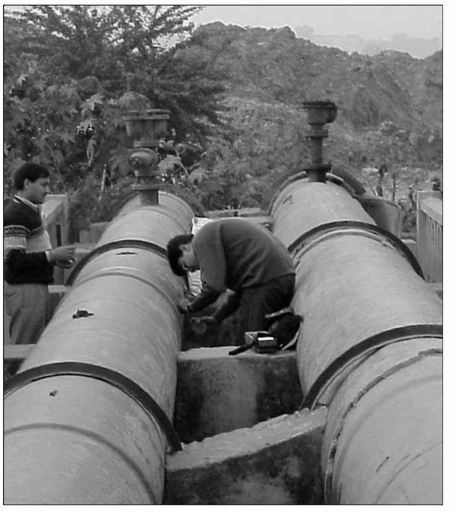
- The combined rated pump capacity of the entire first series system was 25.6 MLD, and the Ranney wells perform at efficiencies ranging between 65 and 80 per cent. The flow finally reaching the Okhla Water Works was around 15.8–18.0 MLD, varying daily. The losses in the mains as measured between the main header at one of the first series Ranney wells and Okhla Water Works on different days also ranged between 6 and 14 per cent. A 24-hour study also established losses in a similar range.
- Similarly the combined efficiency of the second-series network (with respect to flow recorded at one intermediate location, Barapullah Nallah) was 65–80 per cent as against its rated discharge of 16.88 MLD plus the discharge from tubewells. Estimates, based on flow measured on different days, are that about 10.4–12.2 MLD of second-series flow reaches the Okhla Water Works. Losses in the mains as measured between Barapullah Nallah and the water works are 4–8 per cent.
- Flow measurement on the Bhagirathi mains could not be undertaken extensively, as the pipe was constructed primarily of pre-stressed concrete and there was low flow in the mains and high pipe thickness. A preliminary estimate of the flow reaching Okhla water works was 54 MLD but different studies undertaken on the network established a flow of less of than 36 MLD.

Like other water audit exercises in developing countries, this exercise suffered from inadequate technical records e.g. descriptive statements, plans and tabulations of the system's physical and geographical characteristics. This made it difficult to identify each facet of the supply scheme before the actual measurements began. The parameters on which information was either unavailable or partially available include network route maps; details of changes made; basic details like age of infrastructure, material of construction of networks, make of components in the supply scheme like pumps and motors and other specifications. As neither water production nor consumption is fully metered it is difficult to identify the exact cause of water losses.

The way forward

This pilot study was undertaken as part of a project aimed at developing performance measurement systems for Delhi and Kanpur as well as a manual on water auditing. Following on from this the Delhi water board is now undertaking some water audit studies in parts of its supply networks. The lesson learned from this study include:

- A management information system is needed for managing the water supply, covering the treatment plant, conveyance mains and Ranney wells.
- UFW programmes should become routine operational programmes and not sporadic exercises to be undertaken only when special financing becomes available. The organization should ideally begin with audits of limited and meaningful scope rather than comprehensive water audits that are expensive and which should be undertaken only when there is a strong commitment to implement the audit's recommendations.
- Water auditing should be incorporated into the planning phase for all new, existing, and upgrading projects, and should involve making provisions, wherever possible, for locations where flow metering could be done.
- Managers sometimes pay lip service to operation and maintenance (O&M) problems in the existing facilities. The pressure to provide services to a growing population should not put undue strain on realistic O&M budgets.
- Total available water should be continuously compared with gross water demand (i.e. demand including an allowance for UFW) in order to decide whether expansion programmes should be planned or whether, in the shorter term, rationing or pressure reduction programmes are needed.
- Reduction of commercial losses is very important because it helps improve the revenue stream and hence the financial resources almost immediately.
- The different components of a UFW reduction programme and their costs and benefits should be carefully determined to arrive at a cost-effective strategy. In general, domestic meters should be taken out of service every five to seven years and completely overhauled. All interventions need to be analysed and the causes of malfunction or breakage recorded, so as to guide finance procurement decisions and to help in deciding whether part or all of a network or plant should be upgraded or replaced.
- Accountability is probably the most important factor that will induce effective management of basic services by suggesting how to take the necessary steps in the right sequence.



The pipe surface is prepared before the flow meter is mounted

Reference

1 ADB (1997) Second water utilities data book: Asian and Pacific Region.

About the authors

Harpreet Singh Kandra is a Research Associate with The Energy & Resources Institute (TERI), New Delhi, email: hskandra@teri.res.in
Rakesh K. Johri is a Fellow at TERI, and Amit Kapur is with the Center for Industrial Ecology, School of Forestry and Environmental Studies, Yale University, USA. The contributions of TERI colleagues who worked on the project are thankfully acknowledged.