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Significance of losses in water distribution systems in India

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Effective management of water supply systems consists in supplying adequate quantities of clean water to the population. Detailed pilot studies of water distribution systems were carried out in 9 cities in India during 1971-81 to establish the feasibility of a programme of assessment, detection, and control of water losses from supply systems. A cost-benefit analysis was carried out. Water losses from mains and service pipes in the areas studied amounted to 20-35% of the total flow in the system. At a conservative estimate, the national loss of processed water through leaks in the water distribution systems amounts to 10^{12} litres per year, which is equivalent to 500 million rupees.

It is possible to bring down the water losses in the pipe mains to 3-5% of the total flow, and the cost incurred on the control programme can be recovered in 6-18 months. Appropriate conservation measures will help in achieving the goals of the International Water Supply and Sanitation Decade to provide clean water for all.

Effective management of water supply systems consists in supplying adequate quantities of clean water to the population. So far, little attention has been paid to water conservation in most of the water supply systems in India. The reasons for this indifference may be attributed to a lack of awareness of the direct and indirect benefits to be gained from routine, preventive maintenance, and to a lack of funds for staff and monitoring equipment.

Detailed pilot field studies of water distribution systems were carried out in 9 Indian cities, using specialized field techniques and scientific procedures, at the initiative of the National Environmental Engineering Research Institute, Nagpur. Surveys were done in Ahmedabad, Aurangabad, Bombay, Calcutta, Jaipur, Lucknow, Madras, New Delhi, and Surat, during the period 1971-81 to establish the feasibility of assessment, detection, and control of water losses in mains and service pipes. A cost-benefit analysis was carried out. The approach adopted required careful planning and preparatory work, and was very labour-intensive and time-consuming.

Loss of water from a distribution system can occur as a result of:

— leakage from reservoirs;
— leakage from water mains through faulty joints or corrosion;
— leakage in service pipes and fittings inside or outside the consumers' premises;
— leakage through abandoned service pipes.

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These losses will be intensified if the pressure in the distribution system is unduly high.

In addition to losses from the delivery system itself, consumers may waste water by failing to turn off taps when not needed, or using excessive amounts for washing vehicles, watering the garden, etc. It may be feasible to reduce such waste by education and by metering the consumers' premises. However, system losses must be assessed and controlled by systematic waste and leakage detection, followed by prompt corrective action.

METHODS

Leakage can be considered as the amount of potable water lost from a supply source in transmission and distribution, other than by deliberate or controllable action.

The total leakage from the mains, laterals, and portions of service pipes or communication pipes to the consumers' premises was assessed for a zone of about 250-350 house service connexions. This was carried out by closing all the boundary valves and stop taps to the consumers' connexions, and allowing the water to enter the system through a single feeder pipe via a bypass meter. The recorded flow thus depicts the waste due to leakage in the mains. If the recorded waste flow was considered excessive, further tests were carried out to localize the leaks. This was carried out by a "step test", in which the size of the zone was reduced systematically, by closing the internal valves one by one, and the flow into the system noted at each

step. By ensuring that the system was brought to a "tree" system (i.e., with no closed loops), the stepwise isolation of a zone or subzone of mains was achieved and the possible sources and extent of wastage through leaks could be found in a short stretch of mains pipe. The exact location of leaks was carried out at night, by means of sounding rods and/or an electronic leak detector, after the exact alignment of pipes had been determined using either existing records or an electronic pipeline detector. This technique was possible wherever the supply to the system was intermittent. In cases where the supply was continuous, losses were reflected in the minimum recorded night flow.

RESULTS

The pilot studies in 9 cities revealed that 20–35% of the total flow in the water distribution system is lost through leakage from the mains, communication, or service pipes, and valves. This amounts to 40–85 litres per person per day. (The per capita water supply in Indian cities is between 100 and 200 litres per day.) The leaks also result in the deterioration of the quality of water (from aesthetic and microbiological aspects), possibly leading to the outbreak of water-borne diseases such as typhoid fever, hepatitis A, and gastroenteritis.

At a conservative estimate, the national loss of processed water through leaks in the water distribution systems amounts to 10^{12} litres per year, which is equivalent to 500 million rupees or approximately US$ 55 million (assuming that the average cost of processed water is 0.5 rupees per 1000 litres). In addition, there is a significant but unquantifiable economic loss as a result of public health problems arising out of the deterioration of the quality of the water in the network.

Most of the leaks in the pilot zones in the nine cities occurred in house service pipes, communication pipes, ferrule connexions, and couplings; a few leaks were found in valves, mains pipes, and joints. The galvanized iron pipes were often found to be corroded, especially when they were in soils that contained clay, humus, and moisture.

DISCUSSION

Through a systematic programme of preventive maintenance of water distribution systems, it is possible to reduce losses from such systems to 3–5% of the total flow. There are noticeable improvements in pressure and flow of water from taps after leaks have been repaired. Obviously, improvements in water quality and flow lead to a reduction in the incidence of water-borne diseases.

In setting up a maintenance programme, the aims should be to:

1. ensure proper installation, regular checking, care, maintenance, and calibration of meters and pressure gauges, so as to obtain correct and reliable readings;
2. develop a systematic approach to detection and control of water losses in the supply system, especially in transmission and distribution, and proper maintenance of valves, stopcocks, etc.;
3. maintain effective vigilance to detect and prevent unauthorized connexions to the system;
4. set up a field-oriented training programme for engineers, supervisors, technicians, and semi-skilled workers;
5. obtain the necessary instruments and equipment.

Manpower and equipment requirements

A separate division should be created in each waterworks to carry out systematic checks of leakage and water quality. Each division should consist of the personnel shown in Table 1. One division should be

Table 1. Staff required to carry out a programme of preventive maintenance of a water distribution system[a]

Staff	No. required	Responsibilities
Assistant Engineer	1	Overall supervision and control of programme
Overseer/supervisor or junior engineer	3	Supervision of field work
Chemist/bacteriologist	1	Analysis of water samples
Valve operators, fitters, plumbers, and meter readers	8	Routine field work
Instrument mechanic	1	Repair and care of instruments
Field technician	4	Sounding and pipe alignment
Draughtsman	1	Drawing and updating of plans of network
Record keeper/clerk and typist	2	Office work
Unskilled labourers	6	Assisting fitters and plumbers
Driver	1	Transport

[a] The monthly salary bill would be around 15 000 rupees.

adequate for a city with a population of up to about 1 000 000; for larger cities, two such divisions, supervised by a full-time executive engineer, will be required. For major repairs and replacement of pipes and valves, support should be obtained from operation and maintenance and project departments of the water authority.

Each maintenance department should also have the equipment listed in Table 2, the total capital cost of which is around 150 000 rupees. A jeep and trailer costing about 100 000 rupees is also essential for field work. An initial capital expenditure of about 250 000 rupees is therefore needed for equipment and transport. The annual expenditure for personnel and related items and project work would be 200 000 rupees. Allowing for a depreciation of 10%, the recurrent costs for instruments and transport work out to 25 000 rupees per year.

Table 2. Equipment required to carry out a programme of preventive maintenance of a water distribution system

Type of equipment	No. required
Pitometer	1
Revenue (bypass) water-meters	3
Mobile waste-detection (bypass) meter	1
Electromagnetic pipe and cable locator	2
Electroacoustic leak detector	1
Valve box locator	1
Sounding rod and/or aquascope	1
Road measurer	1
Pressure gauges	4
Pressure recorders	2
2-way radio	1
Supplementary plumbing, joints, hose-pipes, etc.	one set

Financial implications

The cost of water for domestic purposes is 0.50–0.80 rupees per 1000 litres.

Assuming that an average of 25 litres of water per capita per day could be saved by a waste survey and detection programme and that initially one division could cover a zone with a population of about 25 000, the immediate savings would be

$$\frac{0.5 \times 25000 \times 25 \times 365}{1000} = 114062.5 \text{ rupees per year,}$$

while the annual expenditure (including depreciation on instruments and transport) would be 225 000 rupees per year.

In addition, unquantifiable benefits would arise from such programmes, such as improved pressure and flow to the consumer, updating of distribution system plans, consumer satisfaction, improvement in water quality, and associated reduction in health hazards.

Table 3 provides information on the cost of waste assessment and control in the pilot projects. It may be noted that the expenditure incurred in the initial stages of the programme will be higher than that for subsequent work in the same zone, since much time, labour, and expenditure are involved in the detailed preparatory work. This consists in updating the distribution system plans, preparing an inventory of pipes, valves, connexions, and houses, providing valves and bypass arrangements, etc.

CONCLUSIONS

It is incumbent on each water authority to have a separate division with the necessary trained personnel and equipment, to carry out a continuing programme of preventive maintenance of water supply distribution systems.

Table 3. Cost of waste assessment and control in the pilot projects, 1971–80

City	Population	Labour cost (rupees)	Material cost (rupees)	Supervision	Total cost (rupees)	Period of recovery of expenditure (months)	Total time taken	
							Preparatory work (months)	Field work (months)
Bombay	8 000	–	–	–	11 000	5.5	4	1.5
Madras	2 620	5 485	14 615	20 050	40 150	1.5	3	1.5
Aurangabad	6 180	1 169	5 330	2 495	8 994	20	3	1.5
Ahmedabad	3 260	9 330	18 200	2 000	29 530	18	4	1.5
Surat	8 950	11 000	91 540	4 000	106 540	15–18	6	4

In view of the goals of the International Water Supply and Sanitation Decade to provide clean water to all by 1990, conservation of water and preservation of water quality are of tremendous importance, particularly in view of the limited water resources available.

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RÉSUMÉ

IMPORTANCE DES PERTES DANS LES RÉSEAUX DE DISTRIBUTION D'EAU EN INDE

Bien gérer les réseaux d'approvisionnement en eau, cela veut dire fournir en quantités suffisantes de l'eau propre à la population. Jusqu'ici, on ne s'est pas beaucoup intéressé à la conservation de l'eau dans la plupart des réseaux d'approvisionnement en Inde. Des études pilotes détaillées des réseaux d'alimentation en eau ont été faites dans 9 villes indiennes à l'aide de techniques de terrain spécialisées et de méthodes scientifiques. Il s'agissait d'évaluer l'aptitude des programmes à déceler et maîtriser les pertes d'eau dans les conduites et les canalisations de raccordement. Une analyse coût/avantages a également été faite. L'approche adoptée, qui demandait une planification et des préparatifs soigneux, a pris beaucoup de temps et exigé beaucoup de main-d'œuvre. On a constaté que les pertes d'eau dans les conduites et les canalisations de raccordement des villes indiennes représentaient entre 20 et 35% du débit total du réseau. D'après une estimation prudente, les pertes d'eau traitée dues à des fuites dans le réseau d'approvisionnement représentent pour l'ensemble du pays 10^{12} litres par an, soit 560 millions de roupies.

Or, un programme préventif d'entretien permettrait de ramener les pertes d'eau dans les conduites à 3-5% du débit total. Il faudrait notamment:

— créer au service des eaux une division à part chargée de repérer et de maîtriser les fuites;
— obtenir des lectures correctes et fiables des compteurs et des jauges;
— adopter une approche systématique et scientifique de l'évaluation, de la détection et de la maîtrise des pertes d'eau;
— assurer une surveillance efficace pour repérer et empêcher les raccordements illégaux;
— mettre sur pied un programme de formation orienté sur la pratique à l'intention des ingénieurs, des responsables de l'encadrement, des techniciens et des ouvriers semi-qualifiés;
— procurer les instruments et le matériel nécessaires.

Le coût d'un tel programme de détection et de contrôle des pertes pourrait être récupéré sur une période de 6 à 18 mois; on devrait pouvoir ainsi contribuer à la réalisation des objectifs de la Décennie internationale de l'eau potable et de l'assainissement, qui est de fournir à tous de l'eau propre.