CIVIL ENGINEERING STUDIES

SEMINAR

ON

WASTE CONTROL AND CONSERVATION OF WATER

BY

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M.E. CIVIL ENGINEERING (ENVIRONMENTAL) STUDENT

THESE STUDIES DEAL WITH CURRENT ACTIVITIES IN THE DEPARTMENT. THEY SERVE AS PROGRESS REPORTS OF MAJOR INVESTIGATIONS., FINAL REPORTS OF MINOR INVESTIGATIONS AND IN GENERAL AS A MEANS FOR DISSEMINATING INFORMATION READILY.

DEPARTMENT OF CIVIL ENGINEERING

INSTITUTE

THAPAR COLLEGE OF ENGINEERING AND TECHNOLOGY

(DEEMED UNIVERSITY)

PATIALA (Pb.) INDIA

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CERTIFICATE

Certified that the Seminar on "Waste Control and Conservation of Water" which is being submitted by Er. Amarjit Kumar in partial fulfilment for the award of Post - Graduate Degree in Civil Engineering (Environmental), is a record of student's own work carried out by him under my supervision and guidance.

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Dated: 2. 3. 1988

ACKNOWLEDGEMENT

I wish to acknowledge my sincere gratitude and deep sense of respect to Prof. T.K. Bansal, Assistant Professor, Department of Applied Sciences, Thapar Institute of Engineering and Technology (Deemed University), Patiala, for his valuable guidance, timely suggestions and consistant encouragement and inspiration to prepare this Seminar Report.

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SYNOPSIS

In a developing country like our's, the demand for the supply of a good quality water is increasing day by day, due to the rapid increase in population and increased standard of living of the people. The increased industrialization, which plays a significant role in the process of development of a country, also requires a huge quantity of water.

Since water resources are limited, so the problem of water shortage and its pollution is causing a great concern to the Government as well as to each one of us. In order to make available enough quantity of potable water in future, to meet its ever increasing demand, we have to think in terms of waste control and conservation of water. In this seminar report, an attempt has been made to give a brief account of the methods of waste control as well as of the conservation of water.

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CHAPTER - 1

1. Introduction

Due to manifold increase in population and rapid growth of civilization, round the globe, water requirement of human beings is increasing at a fast rate and is presenting a great challenge to the Public Health Engineers. Even the properly designed water supply system with due attention towards future population growth, is proving to be inadequate within a few years. To face this problem, water supply in almost all big cities is made intermetant, but that too is not the true solution, as this practice increases peak hourly demand of water indirectly. Over and above, the drastic cut in electricity supply makes the situation difficult even to supply the desired minimum quantity of water, rendering the water crises more pronounced. Now-a-days all the big cities of the country eg. Delhi, Bombay, Calcutta and Madras are suffering from acute shortage of potable water. Although the problem of water crisis seems to be very complex with no immediate effective solution, yet this is not new, as it is also experienced in all the advanced countries of the world. A thorough investigation of this problem reveals that it can be tackled from two angles.

(i) Augmentation of water supply from additional source like use of sea water in coastal areas or reuse of waste water after necessary treatment, and

(ii) Water conservation, which implies consuming only minimum quantity of water and preventing wastage of treated water, howsoever small quantity it may be.

The first technique in which a great deal of instrumentation and advanced technical know-how, is involved, ~~there~~ ~~by~~ leading to a substantial increase in the cost of treated water. So the immediate solution will be to conserve water. The municipal authorities try to prevent leakage in the water distribution systems and the withdrawal of water from unauthorised tapping, but they do not have any effective control in this respect inside the building.

Water consumption of course, has been reduced to a certain extent by introducing water meters in the distribution line. Since the water charges are very nominal, so sometimes the users do not care for the wastage of water. Therefore, an attempt has to be made by municipal authorities to educate the people about the proper use of water. They should be persuaded to use modified types of water supply and sanitary appliances in their houses which conserve water. The various methods and general aspects of water saving, which may prove to be effective in conserving water inside the building as well as outside and also leading to the control of water pollution, are discussed in this seminar report.

CHAPTER-2 : WATER CONSERVATION

2.1 Water Leakage

The total quantity of unaccounted water going as waste can be assessed by carrying out a systematic waste and leakage detection survey. Such a programme xx should be continuing one as new water leakages will crop up in due course of time. The problem of water leakage can be minimised by adopting prompt corrective measures and educating the consumers not to waste the most valuable natural resource. Systematic metering of consumer's water consumption, billing and recovery of dues will help in the reduction of wastage of water inside the consumer's premises.

Wastage of water due to leakages[1] in the distribution system in some cities of India are shown in the table No.1.

The experiments carried out by Liverpool Corporation U.K. have revealed that the loss of just one drop of water per second amounts to a loss of 8 gallons of water per week. The quantity of water that goes waste on account of leakage through holes of different sizes at 45 lb.[2] per square inch pressure is shown in table No.2.

2.2 Wastage of water

Although the leakage of water is also a case of wastage of water, but still there are certain other methods through which water is wasted, these are mentioned as below.[3]

1. Overflow or leakage from reservoir, pipe mains, appurtances and service connections.

2. Unauthorised or unknown consumption of water and wastage of water through unused or abandoned connections.

3. Undue consumption of water by consumers due to excessive use of water for gardening, washing vehicles, floors etc.

4. Misuse of water for miscellaneous purpose.

5. Failure to turn off the taps in premises willfully or inadvertently.

6. In case of intermetant supply of water, emptying of stored water in a receptacle when fresh water comes and keeping the tap open throughout thus allowing water to waste over the receptacle.

7. Unduly high pressure in the distribution system intestifying leakage and waste.

8. Water although legitimately used, but not properly accounted for (Say public stand posts, places of worships etc.) and;

9. Error of measurement at any stage in production supply and distribution of water.

2.3 Water Conservation Methods[4]

The various methods used for conserving water are discussed below. The methods are :-

(i) Structural Method

(ii) Economic Method

(iii) Operation Method

(iv) Socio Political Method

(v) Water Supply alternatives i.e. recycled or reused water.

2.3.1 (i) <u>Structural Method</u>

Water saving and metering equipments are physical devices that can reduce water demand -

(a) Water saving devices can be divided into two groups -

(i) Retrofit devices

(ii) Devices originally installed in new housing.

About 75% of the inhouse water consumption generally occurs in bath room. Consequently the design of retrofit devices and low flow plumbing fixtures focuses on showers, faucets and toilets. Retrofit devices, such as toilet dams, faucets acrators and shower flow restriction can be installed in existing structures, but maintenance and operation costs are relatively high as compared to plumbing fixtures, specifically designed for low water use.

(b) Metering of customer's water consumption provides a feeling of using less water or to reduce the demand. It has been proved that metering reduces the demand for water, particularly water used for outside purposes. Since flat rate consumers cannot be billed according to the quantity of water consumed by them, so the wastage of water for unnecessary use of water in their case will be high. Increased price of metered water will also discourage excessive use of water.

2.3.2 Economic Method

Metering coupled with pricing strategies can significantly reduce the demand of water. Flat rate community can reduce their water demand through restrictions and public appeals. Metered communities are generally charged a minimum rate and a uniform price or some type of block rate structure for the amount of water used by them exceeding the minimum amount. Flat rate service areas are usually charged a certain fixed price to single family residential customers. Additional charges based on the lot size of family or number of rooms may be imposed.

There are three types of pricing commonly used by water utilities -

(i) declining block rate

(ii) uniform rate

(iii) inclining block rate.

The marginal cost of water decreases with increased usages under the declining block rate structure. The uniform rate means the marginal cost is constant, and the inclining block rate provides an incentive to ~~the~~ conserve water because the marginal cost of water increases with increased usage.

2.3.3 Operational Methods

Water consumption restrictions can be imposed both on metered as well as flat rate communities. The restrictions are generally imposed to reduce the peak hour demand and for maintaining pressure in the water supply system. Overall reduction of water demand is also necessary in some cases because of insufficient capacity of the water treatment plant. The restrictions imposed for outside water uses may be for certain days or for certain hours of a day.

2.3.4 Socio-Political Methods

Socio Political methods of water conservation ~~af~~ are those that require framing and modification of regulations or ordinances designed to reduce water demand by imposing lawn size limitations, control of population growth, and control of land scaping practices.

2.3.5 Water Supply Alternatives.[5]

Recycled or reused water, in recent years has become a more practicable alternative to alleviate water supply problems. But reuse of water does not reduce the demand for water within a community. However, a glance at the figures given below indicates enormous amounts of water used by industries ~~would~~ it reveals the imperative necessity of conserving and reusing of water. A fully integrated steel mill requires about 15000 litres of water per tonne of steel, while a rolling and a drawing mill need one lac litres of water per tonne of production.[1] The manufacturer of one automobile requires 38,000 litres of water, while production of one tonne of cotton needs 2,50,000 litres of water. The chemical industries also use enormous quantity of water e.g. a tonne of ammonium sulphate production requires 8,35,000 litres of water, soda ash 6,26,000 litres and calcium carbide 1,25,000 litres. To produce a tonne of fine quality paper nearly 10,00,000 litres of water is required, while a tonne of prepared meat needs 23,000 litres of water.

In a thermal power plant, the condenser uses large quantity of water. The total cooling water requirement of a 210 M.W. unit is nearly 30 million litres of water per hour. In the processing of fibres and finished cloth, the water requirement ranges from 1,20,000 to 2,70,000 litres per tonne.

2.4 Techniques reducing water consumption [6]

Since water is available in limited quantity so its conserving techniques should be used. Reduced water consumption will make the water available for a large number of people and a large number of industries. It will also help in the control of environmental pollution by reducing the quantity of waste water coming out of houses and industries.

The various techniques which are helpful in reducing the water consumption are mentioned below :-

2.4.1 Use of Spray Taps

Consumption of water for a required purpose can be cut down by using taps which give out water in the form of a spray, unlike the conventional taps which deliver water in the form of single jet. The decrease in the cross sectional area of outlet at the spout of the tap increases the water cleaning efficiency. Consequently it reduces operational time of the tap, thereby reducing the quantity of water consumed. Hence the use of spray taps economises water. A water economy of about 50 percent has been reported in the literature. This technique is specially effective where taps are used for cleaning and washing purposes e.g. in the case of wash-hand-basin and kitchen sinks.

2.4.2 Prevention of water loss through leaking taps

It is well-known that thousands of litres of water gets wasted everyday through the leaking taps. This round the clock wastage is mainly due to ineffective washers. Hence standardisation of washer material should be the prime step towards water conservation. Different materials have been tried but it has been observed that washers made from polyethylene fibres last longer and also give better performance. The use of plastic taps which eliminates absolute use of washers may also go a long way in preventing wastage of water.

Hence use of good quality plastic taps or polyethylene fibre washers with conventional metallic taps is recommended.

2.4.3 Reduction of Terminal Pressure Requirement

Natural plumbing code U.S.A. prescribes a minimum terminal pressure of 0.563 $Kg./Cm.^2$ to be available at any point, in the water distribution line. The National Building Code of India recommends a terminal head of 0.25 kg per centimeter square. According to both the recommendations, in a gravity feed system of water supply, it is not possible to serve the top most storey of a multi-storey building over which water tank is placed. Moreover the terminal pressure recommended is very much on the higher side which causes unwanted splashes. On account of these facts it was felt to study the pressure requirement at the water tap for its better and economical performance.

Since the water discharge through a tap depends on the water head available at the point. Therefore, greater the head the more will be discharge and also the splash. An experiment was performed to find out the discharge through 12mm ($\frac{1}{2}$") tap at various pressures. The test has revealed that the most workable pressure in Indian conditions is 0.176 Kg/Cm^2 at which the discharge is about 2.5 gpm. A pressure of 0.176 Kg/Cm^2 is equivalent to a water head of 1.76m. and 2.5 gpm. flow rate is approximately equal to 14 litres/per minute. Hence a minimum residual water head of 0.176 Kg/Cm^2 is recommended at any point in the distribution line. As shown in figure No.1.

2.4.4 <u>Dual Flushing Cistern</u>

In residential houses generally urinals are not provided. As a matter of fact the same W.C.(water closet) is used for both urination and defecation purposes and after every use the full capacity of the flushing tank is discharged resulting in the wastage of a huge quantity of treated water, but water can be conserved by the installation of a dual flushing cisterns in place of an ordinary flushing tank. In this system a cistern can discharge either a predetermined fraction of full capacity or the full capacity of water as desired by the user.

The dual flushing cisterns are of two types which are dissussed below :

2.4.4.1 <u>Syphonic Type</u> :-

The existing type cistern can be converted into a dual flushing unit by making provision to break the syphon at the predetermined level of water in the tank depending on the fraction of water discharge required. To operate the fractional discharge the chain is just pulled and then left. When the water level reaches the prefixed level air enters in and breaks the syphon. For full discharge the chain is pulled and held in that position untill the full capacity is discharged. The necessary change in the existing cistern is simple and can be done even by an ordinary plumber. The extra cost involved is about Rs. 35.00. The details of the extra cost are as follows:-

Cost of making hole in the syphonic chamber.	Rs. 10.00
Carriage of chamber to market and back.	Rs. 5.00
Labour charges for removing and refixing the chamber.	Rs. 20.00
	Rs. 35.00

If this change is done at the manufacturing stage then the cost of the new unit will certainly be comparable with prevailing market rates for existing cisterns. Fig. 2 shows the details of a dual flushing tank (syphonic type).

2.4.4.2 (ii)Bell Type Cistern With Knob Control

The conventional bell type flushing cistern can also be converted into a dual flushing unit. The conversion is made by inserting a 6 mm dia rubber tube in the bell of the cistern at a predetermined level depending upon the fraction of water discharge required. The other end of the tube is fitted to a plastic pipe with a stop cock at the end to control the entry of air. The cistern gives ful discharge with stop cock closed and fractional discharge with stop cock open. Therefore before pulling the chain the stop cock is adjusted at the desired position marked on the plastic disc. As shown in fig. 3. Thus for full discharge the chain has not to be kept pulled through out the time of discharge. It is just pulled and left as per traditional practice. The extra cost in the conversion is about Rs. 40/-. The details of the extra cost are given below:-

Cost of making hole in the bell including threading.	Rs. 3.00
Cost of knob/ stop cock.	Rs.15.00
Cost of Nipples.	Rs. 2.00
Cost of block & screw	Rs. 3.00
Cost of 6mm Ø 4'-0"	Rs. 2.00
Labour charges including carriage.	Rs.15.00
	Rs. 40.00

Both these types of dual flushing cisterns have been patented and licensed through National Research and Development Corporation (NRDC) New Delhi.

The following illustration explains that a family of 5 members can save water to the extent of 4500 litres in a month by adopting a new type of cistern.

Let each member of a family uses W.C. for urine purpose 4 times a day i.e. in 24 hours.

Water discharged partially (by using dual flushing cistern)	5 litres
Total capacity of the tank ie. cistern.	12.5 litres
Water saved by using dual flush cistern for a single uee.	12.5-5 litres = 7.5 litres.
Water saved with 4 time use.	7.5x4=30 litres
Water saved by the family of 5 members in a day.	30x5 = 150litres
Water saved during a month	30x150=4500 "

If one family can save this much amount of water on using this new technique, it can be well imagined that how much amount of water will be saved in the big cities of the developing countries.

2.4.5 Sanitary Appliances Of Improved Design

There is a large scale wastage of treated water due to repetition of flushing in case of improper functioning of the W.C. bowls or pans. This valuable water can be saved in large quantities by installing sanitary appliances of improved design. This is mainly due to the improper design of the seat. Normally the Indian squatting type W.C. pan has got circular water seat surface where as the European type provides a rectangular one.

Efficiency of a W.C. (Water closet) is dependent on the proper functioning of both W.C. Bowl or pan and the flushing cistern. Various types of flushing systems are available in the market. But it has been observed that many of these 3 gallons (13.5 litres) tanks fail to give the desired flushing effects. In some cases these tanks take as much as 15 seconds to discharge water for efficient flushing, while it is desired that water must be discharged at a rate which should not be less than 3 gallons (13.5 litres) in 9 seconds. The municipal authorities should insist on the public to use only the approved quality of flushing cistern so that water consumption can be reduced.

For European water closet (E.W.C.) bowls, the minimum water seat surface area recommended in I.S.I. 2556 Code is 150 cm^2. But investigation has shown that even with 15 litres high level flushing the effeciency is hardly 60%. By gradually reducing the water seat area, the efficiency is increased. When the water seat area is 75 cm^2, the efficiency is about 100%. Considering the velocity of flushing water required to drag out all the suspended matter through the water seat for better performance of E.W.C. bowls, the seat area should not be more than 75 cm^2. Fig. 4 shows the details of a x modified water closet. A reduced seat area, provides a 98% efficiency even with a 6.5 litres tank. The design of the approved bowl seat has been accepted by I.S.I. authorities and has been included in IS : 2556 II Code.

The In case of Indian type W.C. pans the positioning of holes in the box rim plays an important role in controlling its efficiency. Lesser is the distance between the holes, greater will be the efficiency. Experimentally it has been observed that a distance of 40mm from centre to centre of the holes give better performance.

CHAPTER-3

3.1 Financial Implications:-

The cost of water varies from paisa 50 to Paisa 80 per 1000 litres of water for domestic purposes.

Assuming on an average, 25 litres per capita per day (on conservative basis) of water could be saved by waste survey and detection of leakage in distribution system, and one establishment unit could cover in the initial stages a distribution zone with population of 25,000 to 35,000 in a year, the approved saving would be :

$$\frac{25 \times 0.80 \times 35,000 \times 365}{1000} = \text{Rs } 2,55,500 \text{ per year.}$$

While the annual expenditure (including depriciation for instuments) could be Rs 2,75,000/- per year. Subsequently for leak detection in the same zone they can cover, double the pupulation from 50,000 to 1,00,000 due to earlier preparatory work.

In addition, the main unquantifiable benefits arising out of such programmes are improved pressures and flows to the consumer, updating of distribution system plan, consumer's satisfaction, prevention of ingress of extraneous pollutant into the pipe and promotion of positive health of the consumers.

3.2 Economic Aspects:

For a fixed net consumption of water in a system the criterion to be satisfied for optimum cost of waste control will be when the marginal cost of reducing losses is equal to the marginal value of water loss retrived or avoided (based on cost of production of water and intrinsic value of xfx safe water). The intrinsic value or worth of safe water may not be the same in all the cases. Efforts for water loss reduction and prevention shall be persued as long as the cost of effectiveness for reduction of waste is comparable to that of producing more water to compensate for the losses.

The criterion for economic and financial viability is the application of cost benefits analysis. It takes sufficiently long time period (5-10 years) in an undertaking for the benefits to outweigh the costs. One has to assess how big is the total efforts and how it should be applied. It becomes difficult to identify and quantify all the costs and all the resulting tengible and intangible benefits. The following guidelines may determine the magnitude or waste control efforts for determining optimum waste levels in an undertaking.

(i) The value of water saved resulting from waste controls should be estimated;

(ii) The appropriate level of effort is likly to vary from time to time or from area to area within the under taking;

(iii) Repair of leaks located should be prompt;

(iv) If the water saved reduces the amount of bulk purchase xxtx then the saving will be related to the bulk purchase rate;

(v) In some systems, the water supply may be quite large and enough to ~~supply~~ meet all demands, inspite of the present rate of wastage. In these circumstances, the benefits from reducing wastage will be limited.

(vi) If the undertaking can foresee the time when significant additional capital expenditure will be necessary in order to maintain supplies and if the effect or reducing the wastage would be to enable the date of such investment to be deffered, then the financial advantage from such savings of waste would be related to the amount of interest payment deffered. Since the cost of the new plant is commonly greater then the old this value might well be greater than the present average charge of water.

The cost of waste control work for ensuring certain saving of water goes up approximately as in an exponential curve, as more and more waste has to be controlled and recorded. Initially, the savings and other benefits from intensified leakage control may not be commensurate with the expenditure and efforts incurred and deployment of extra manpower. Subsequent waste control justifying extra cost, manpower and equipment. Such a trend has been shown in fig. 5-A.

The present worth or value of the annual cost over a period for rehabilitation (from the point of view of leakage reduction and control of distribution system) and the present worth or value of the corresponding annual value of water loss saved during the period can be compared. This may also indicate the optimum loss level when the marginal cost of loss reduction equal to marginal value of water saved. Logically, it implies that it may not be an economically viable proposition to aim at zero water loss in the distribution system. The benefit is reflicted in the value of water saved and in turn also avoid the cost of production of extra water.

The present value of annual benefit V_b stream ie. water saved is given by

$$V_b = L_o + \frac{L_1}{1+r} + \frac{L_2}{(1+r)^2} + --- \frac{L_n}{(1+r)^n}$$

Present value of annual cost stream

$$V_c = C_o + \frac{C_1}{1+r} + \frac{C_2}{(1+r)^2} + --- \frac{C_n}{(1+r)^n}$$

Where V_b Value of annual benefit.

V_c Value of annual cost.

$(L_o - L_n)$ - Annual value of water saved.

$(C_o - C_n)$ - Annual cost

r - discount rate

n - number of years

When V_b is greater than V_c (ie. benefits outweigh costs) it is economically viable to make available more water by reducing losses, rather than by augmenting new water supply. As the waste reduction efforts is a continuing programm over a long period, the quentum of efforts to be put in for waste control may be continued and maintained at a level when V_b equals V_c. When V_b is substantially less than V_c the expenditure on the programm and quantum of loss reduction efforts may have to be reduced in course of time. The frequency of waste control programme to be carried out again in the same area depends on available infrastructural facilities and cost consideration. For each water undertaking, there may be an optimum interval of years for the programme to be carried out. It has been shown in fig. 5-B.

CHAPTER-4 :

CONCLUSIONS

The recent crises of drinking water in almost all the cities of the Country can be tackled to a great extent through the following ways.

(i) Augmentation of additional water resources eg. use of sea water in coastal region and reuse of waste water after proper treatment.

(ii) Prevention of wastage of treated water inside the buildings by the

a) Use of polyethylene fibre washers for taps.

b) Use of spray taps.

c) Reduction in terminal pressure requirement during design of water supply system.

d) Use of dual flushing cisterns.

e) Use of standard types of flushing cisterns and modified W.C. seats ie. water conserving fixtures.

No efforts should be spared to minimise the avoidable wastage of water. Publicity drives and exhibitions highlighting the conservation of water theme should be arranged. Suitable rewards or incentives should be instituted to encourage people to contribute new ideas, methods and gadgets leading to the conservation of water.

Even a Country like United States of Amrica with w vast resources has found it necessary to create awareness about the conservation of water and stopping wastage with various measures like pamphlets urging to " Be a leak seeker", to " Use all the water you need, but use it wisely, not wastefully", public service announancements on television, radio etc.

By adopting water conservation techniques we can save an important natural resource. Moreover by xxx saving water we are preserving this important natural resource for the next generation. Therefore it should be our foremost duty to conserve water at all cost, how minute it may be.

CHAPTER-5

A REPORT OF PATIALA WATER SUPPLY SCHEME.

Patiala is an old city and has its water supply based upon tubewells. Previously, the water supply schemes was maintained by the P.W.D. Public Health Department but now (since Ist of April, 1979) it is maintained by the Municipal Committee Patiala. City has a intermittant supply of water, except in some newly built posh colonies.

In side the old city pressure head is not upto the mark. Water is not available on the upper storeys during summer/peak hours. As per the practice there should be at least 8 lb/inch^2 pressure in every pipe line, while releasing a new water connection, but this practice is not maintained. By having 8 lb/inch^2 pressure, water can rise upto approximately 20' height.

After the Municipal Committee took over the charge of water supply, World bank loan was sought to improve the condition of water supply as well of sewerage scheme. Against world bank scheme, Punjab Water Supply and Sewerage Board installed 5 new tubewells, to improve the water supply of the city. On the other side, with the help of World Bank, ~~Water~~ new W.C. (Water closets connections) were installed on loan basis in whole of the city. Approximately 15000 new W.C. were installed. Though these W.C's were without flushing cistern, but still water demand increased, because the flushing was done with buckets.

An assesment was made regarding the wastage of water. It was found that only 60 to 65% of the water produced was billed. This shows that nearly 35 to 40% of the water produced, was wasted through stand posts (Municipal Committee taps), leakages and theft of water. Earlier there were 600 stand posts in whole of the city. Due to negligence of the people, using these stand posts, maximum water was wasted through them. So it was decided to curtail the number of stand posts to conserve water.

Moreover there were approximately 3000 water connection which were without water meters ie. the flat rate was charged from the consumers. This practice also increased the wastage of water as the consumer has to pay a fixed amount for a month and not for the water he is actually using, so they are not bothered for the running of water taps without any use. Now Municipal Committee Patiala is getting all these unmetered connections either disconnected or the meters installed. This practice will certainly boost the pressure of water inside the city. Fig. 6 showing the peak factor before and after metering.

Out of the total wastage of water a greater portion of it goest out through stand posts. People using these do not take care of the water going waste. They misuse this facility and do not bother to close the tap or try to save it from bad elements who steal them as taps are generally taken away by bad elements, with the result water contineously flows through these open taps and gets wasted. With this there is not only a wastage of precious water but also unnecessary increase of load on the sewerage treatment plant which has to handle more quantity of waste water.

The per capita demand of water at which our water supply schemes are designed is 40 gallon/cpd. But generally this is not the actual quantity of water which the consumer gets, because the assumed wastage of water is much less than the actual wastage of water. Table-3 indicates the water consumption of various cities of different countries [8]. Moreover the design quantity of water does not hold good as the population increase is not as per calculations made at the time of designing the schemes. Various design parameters[9] taken into consideration for designing water works projects in the developed countries and developing countries are given in table-4.

The water supply system of the city can be made more effective by adopting the various preventive measures as discussed in this report earlier. Moreover the following steps can further improve the condition of water supply by preventing the wastage of water.

(i) The people using municipal committee taps should be told about importance of water. They should be taught how to use the Municipal Committee taps, ie. to close it when not required

(ii) The M.C. taps should be maintained properly ie. early replacement of defective parts or taps.

(iii) Installation of theft proof taps.

(iv) By penalizing the person misusing the stand post.

(v) By making all the connections metered or disconnecting all the unmetered connections.

(vi) By increasing the water charges.

At present Municipal Committee rate of the water charges is 35 paisa per 1000 litres upto consumption of 15000 litres per month and above 15000 litres/month the rate of water charges is 0.50 paisa per 1000 litres

By conserving water, we not only save water to maintain the ecological balance, but also there are many other benefits, which are given below:-

(a) The underground potable water will last for a longer period.

(b) Operational cost will be less, ie. less water will be required to produce.

(c) The cost of handling waste water will be less.

(d) Less will be drop in pressure, hence more pressure will be there and the water will be available on upper storeys. In turn it will reduce the required height of over head storage tank, ultimately saving of money in water supply projects.

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11. Jain S.R. "Conservation of Water Through Better Plumbing and Sanitary Fitting" Journal of Indian Water Works Association Jan.-March, 1983.

APPENDIX - A

FIGURES

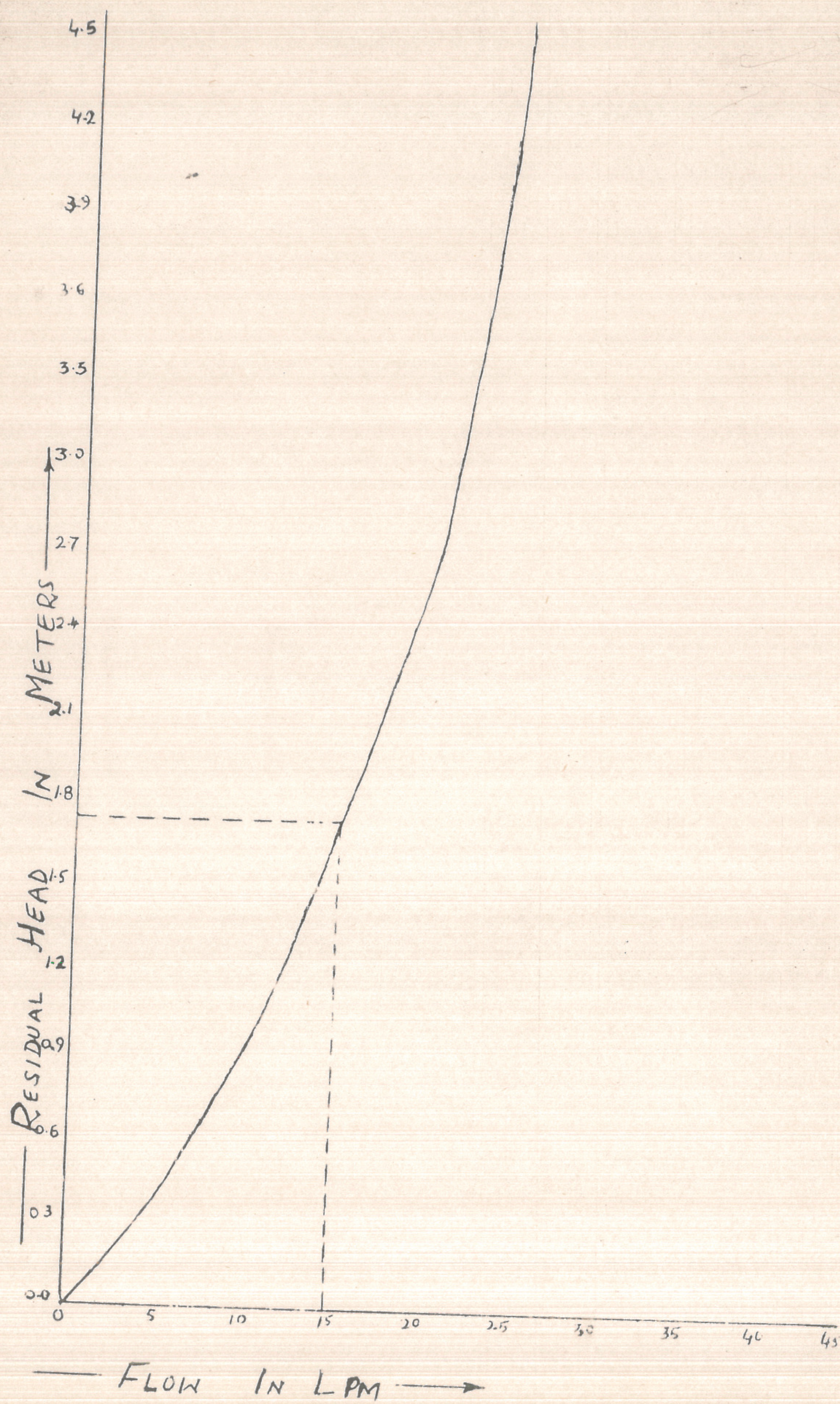

FIG-1 PRESSURE LOSS THROUGH 1/2" BIB-COCK AT DIFFERENT FLOW RATE

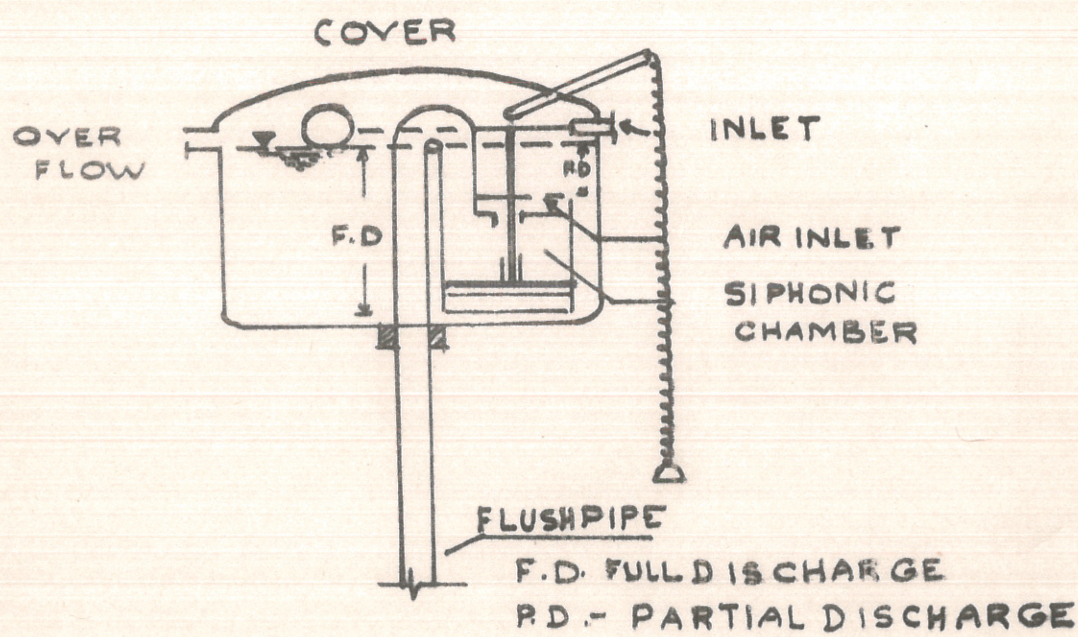

FIG. 2 DUAL FLUSHING TANK (SIPHONIC TYPE)

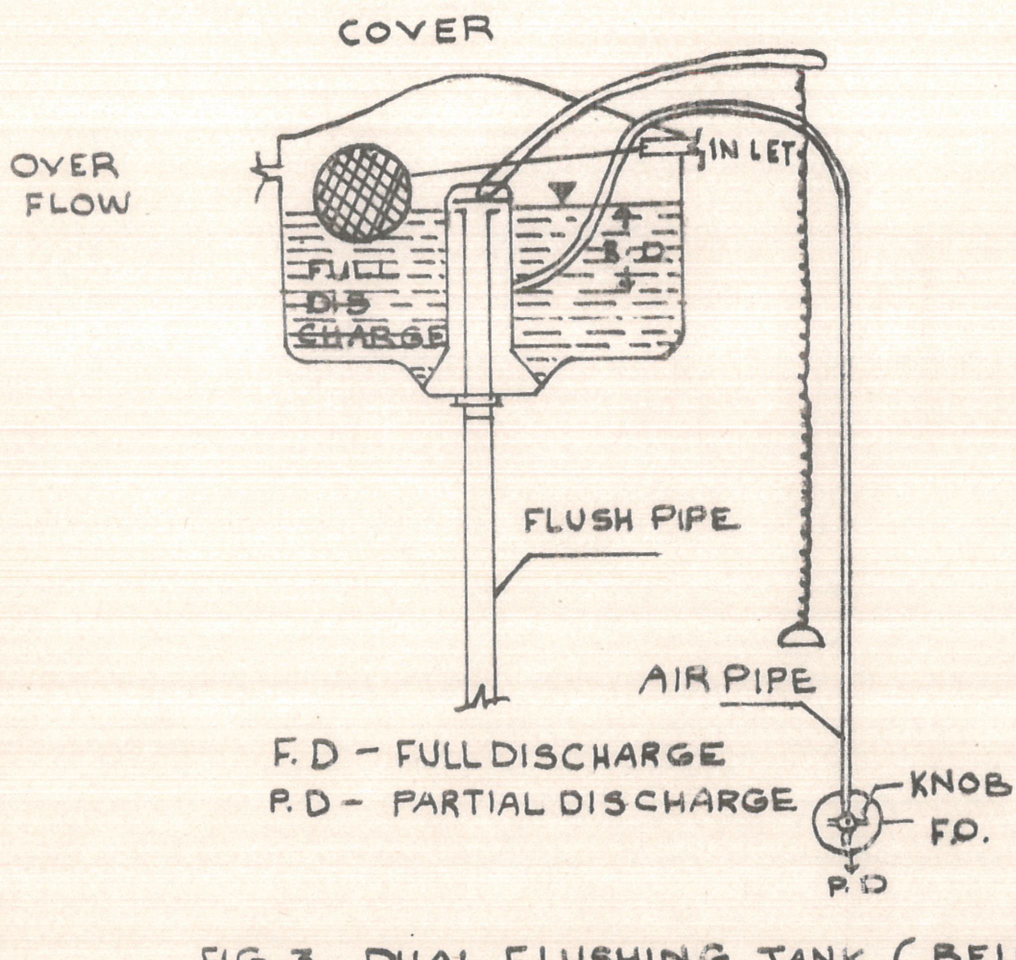

FIG. 3 DUAL FLUSHING TANK (BELL TYPE)

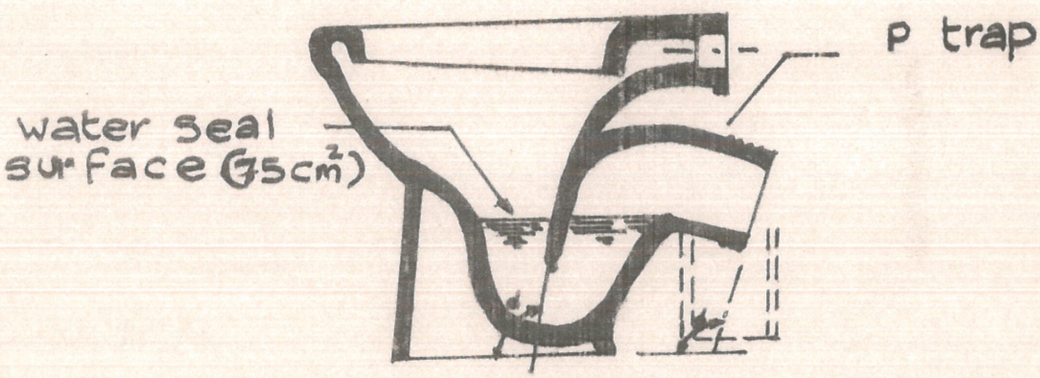

FIG 4. Modified Water closet

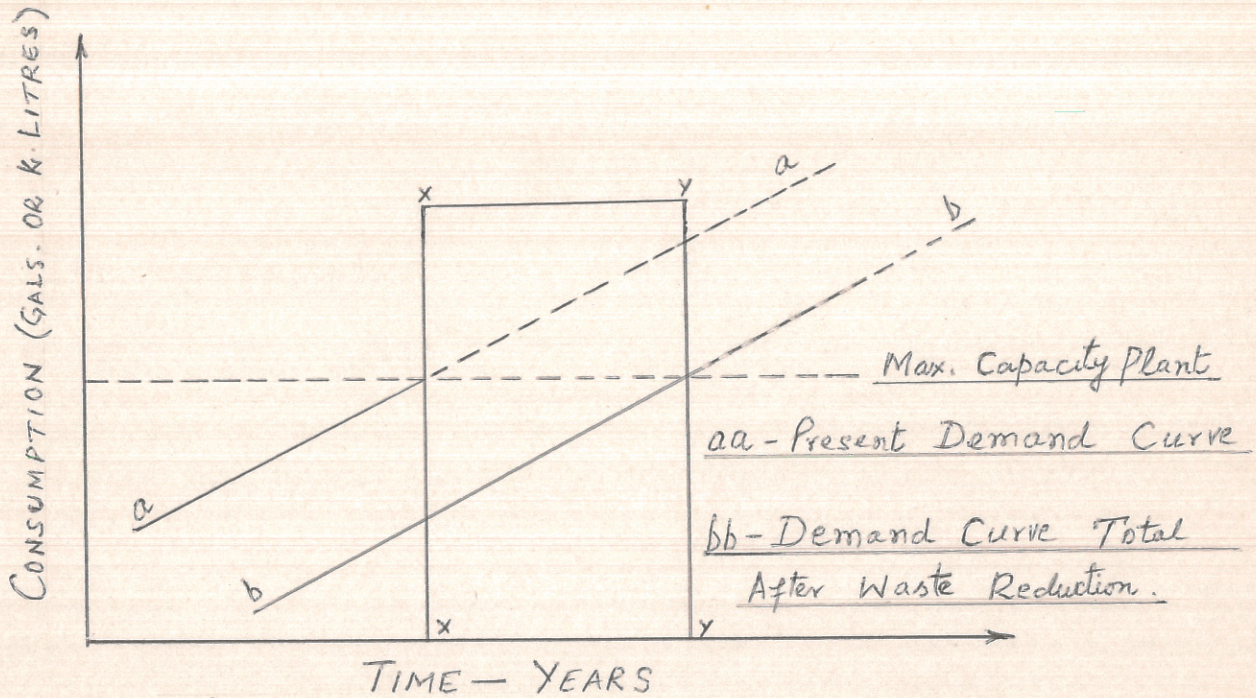

FIG. 5-A DEFFERED INVESTMENT BY WASTE REDUCTION

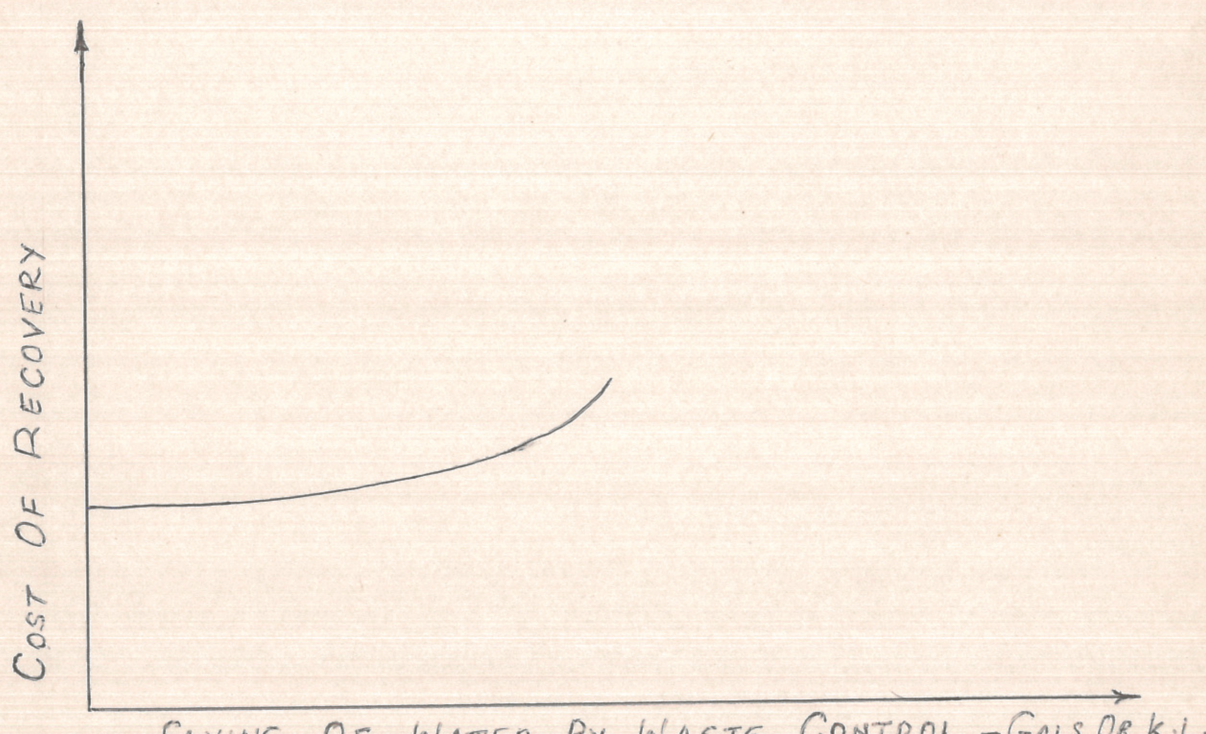

FIG. 5-B RECOVERY COST Vs QUANTITY SAVED

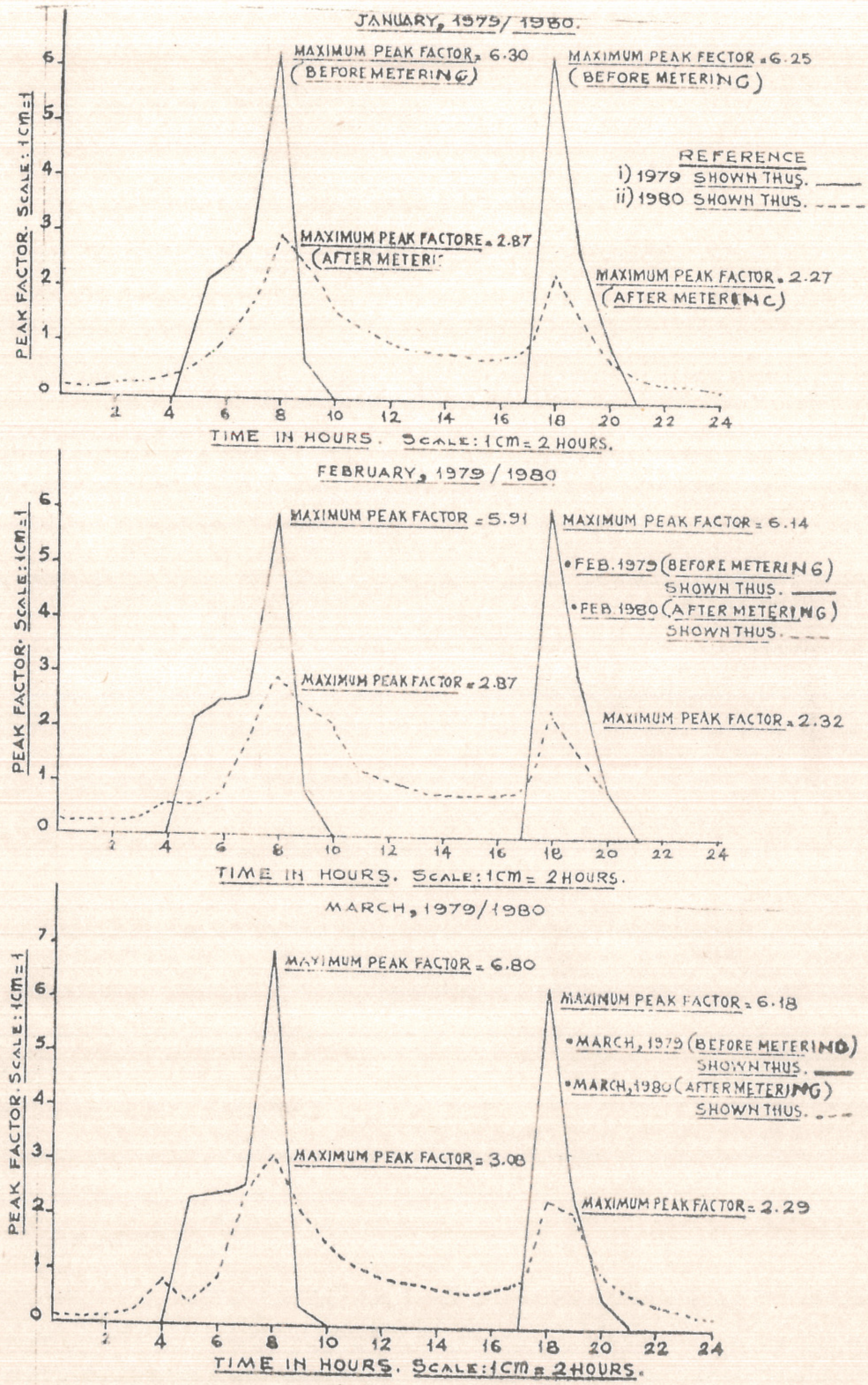

FIG. 5 GRAPHS SHOWING PEAK FACTORS BEFORE AND AFTER METERING

APPENDIX-B

TABLES

TABLE - 1

WASTES DUE TO LEAKAGES IN THE DISTRIBUTION SYSTEMS IN SOME CITIES OF INDIA

Sl. No.	Name of City	Population of each Zone	No. of house connections in Zone	Hours of supply	Percentage of Waste flow	per capita waste flow lit/day
1.	Bombay	8,000	241	15	28.5	60.0
		7,847	281	15	33.0	86.2
2.	Aurangabad	6,177	377	3.5	28.6	16.3
3.	Delhi	1,562	260	13	17.7	—
4.	Madras	2,000	170	6	36.0	75.6
		618		18	3.7	6.4
5.	Lucknow	1,517	149	24	19.0	24.7
6.	Calcutta	15,552	117	24+	24.6	34.0
		7,819	216	24+	25.0	33.1
7.	Ahmedabad	1,555	184	6	20.1	38.0
		1,703	—	5.5	25.5	27.5

Leakages in pipes and ancillaries upto stop sock (excluding plumbing within house), based on *Intermittent water supply*

+ 24 hours supply, but part of time under low pressure.

Note: (1) Most of the leaks were observed at ferrule connections, couplings in service pipes, corrosion in house service pipes and some in valves and joints.

Ref: Status of Distribution system in India with reference to Leaks and carrying capacity by Prof. V. Raman, "Journal I.W.W.A." — Jan. '79. Vol. XI No. 1.

TABLE-2 WASTAGE OF WATER THROUGH LEAKING HOLE[2]

S.NO	SIZE OF THE HOLE	DISCHARGE IN GALLON UNDER 45 P.S.I.	
		per hour	per day
1	1/64"	15	360
2	1/32"	27	648
3	1/16"	160	3840
4	1/8"	192	4608
5	1/4"	450	10800
6	1/2"	2200	52800
7	3/4"	4500	108000
8	1"	8100	194400

TABLE - 3 AVERAGE WATER CONSUMPTION FIGURES FOR SELECTED CITIES

S.NO	CITY	YEAR	GPCD	LPCD
1.	NEW-YORK.	1966	153	689
2.	CHICAGO	1966	231.	1040
3.	MOSCOW	1970	133	600
4.	BOMBAY	1975	51	228.

GPCD → Gallons per Capita per day.

LPCD → Litres per Capita per day.

1. Gallons ⇒ 4.5 Litres

TABLE - 4 DESIGN PARAMETERS

S.NO	PARAMETERS	DEVELOPED COUNTRIES	DEVELOPED COUNTRIES	
			URBAN CENTRES	SMALL COMMUNITIES
1.	PER CAPITA CONSUMPTION (lpcd)*	200-600	150-300	60-120
2.	MIN. PRESSURES (Metres of Water Gauge)	20-50	15	8
3.	MIN. DIAMETRES (In mm)	150	50	30

* lpcd → Litres per capita per day.