NON REVENUE WATER AND LEAK DETECTION IN WATER SUPPLY PIPE LINE

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Abstract:
Non-Revenue Water (NRW) poses a significant challenge to water utilities worldwide, leading to economic losses and environmental concerns. This project delves into the critical issue of NRW, focusing specifically on the innovative techniques and technologies employed in leak detection within water supply pipelines. The study aims to provide insights into the current state of NRW, the impact of leaks on water distribution systems, and the advancements in detection methods that contribute to sustainable water management. Non-Revenue Water, comprising unbilled and lost water within distribution systems, is a pressing issue affecting the efficiency of water supply utilities. This project centres on leak detection in water supply pipelines as a crucial aspect of NRW management. The introduction sets the context for the significance of addressing NRW and the pivotal role of leak detection in minimizing water losses.

Keywords: Non-Revenue Water (NRW), Leak Detection, Distribution systems

1. INTRODUCTION

Water scarcity is a pressing global concern, exacerbated by factors such as rapid urbanization, population growth, and the effects of climate change. In this context, the efficient management of water resources becomes imperative, and a significant challenge arises in the form of Non-Revenue Water (NRW). Non-Revenue Water refers to water that is lost before it reaches the end-user due to leaks, theft, or inaccurate measurements. It represents a critical issue for water supply systems worldwide, leading to economic losses, environmental impact, and reduced water availability. In the context of India, a country experiencing rapid urbanization and grappling with the consequences of a growing population, the management of water resources is of paramount importance. India faces unique challenges in its water supply systems, including aging infrastructure, unauthorized connections, and technical losses, all contributing to elevated levels of Non-Revenue Water. Additionally, the need for effective leak detection technologies is underscored by the increasing strain on water resources and the importance of optimizing the distribution of available water. By exploring the magnitude and causes of NRW, assessing technological advances in leak detection, and examining case studies and best practices, this project aims to contribute valuable insights to the ongoing discourse on sustainable water resource management in India. The implications of NRW extend beyond the economic realm, impacting environmental sustainability and social well-being. It is crucial to not only quantify the extent of Non-Revenue Water in India but also to identify and evaluate the effectiveness of various leak detection technologies and management strategies. Furthermore, understanding the role of government policies, regulatory frameworks, and community engagement in addressing NRW provides a holistic perspective essential for the formulation of comprehensive solutions. Non-Revenue Water (NRW) poses a critical challenge to water supply systems globally, and India is no exception. As a rapidly developing nation with growing urbanization, ensuring the efficiency of water supply pipelines is paramount. This literature review explores the existing research on NRW and leak detection in water supply pipelines within the Indian context. Understanding the extent of NRW in India is crucial for effective management. Numerous studies highlight the alarming rates of NRW across different regions. Causes include aging infrastructure, unauthorized connections, meter inaccuracies, and technical losses. The economic and environmental repercussions of high NRW rates underscore the urgency of addressing this issue.

1.1 Scope of the work:

The scope of this project encompasses a comprehensive investigation into the issue of Non-Revenue Water (NRW) and the associated challenges of leak detection within water supply pipelines in India. The primary objective is to contribute valuable insights to the understanding and mitigation of NRW, focusing on technological solutions, policy frameworks, and community engagement.

1.2 Problem Statement:

- India, with its burgeoning population and rapid urbanization, faces an acute challenge in the efficient management of water resources. A significant impediment to sustainable water supply systems is the pervasive issue of Non-Revenue Water (NRW) – water lost before reaching end-users due to leaks, theft, or inaccuracies in measurement. The high prevalence of NRW in Indian water supply pipelines not only contributes to economic losses but also exacerbates the already critical water scarcity situation.
- The problem extends beyond NRW to the efficacy of leak detection mechanisms within water supply infrastructure. Aging pipelines, unauthorized connections, meter inaccuracies, and technical losses further compound the challenge. This problem statement seeks to underscore the urgency of investigating and resolving the challenges associated with Non-Revenue Water and leak detection in water supply pipelines in India.
- By understanding the root causes, evaluating existing technologies, and proposing effective strategies, this research aims to contribute to the development of informed policies and practices that will mitigate water losses and optimize water distribution systems for the benefit of present and future generations.

1.3 Objectives:

- To understand the existing body of knowledge on Non-Revenue Water (NRW) and leak detection technologies in water supply pipelines in India.
- Approach: Conduct a systematic review of peer-reviewed articles, reports, and relevant publications from academic databases, government agencies, and international organizations.
- Inclusion Criteria: Include studies published within the last decade, with a focus on Indian water supply systems, NRW quantification, causes, and leak detection technologies.

2. LITERATURE REVIEW:

Dr. Anil Kumar in their study to Water is an essential and vital component of life support system. The grounds as well as surface water resources are being utilized for drinking, irrigation and industrial and other purposes. However, due to rapid growth of population, urbanization, industrialization and agriculture activities, water resources are under stress. There is growing concern on the deterioration of water quality due to geogenic and anthropogenic activities.

A. AyadA. KhalifaM. EL FawyA. Moawad This paper describes the development of an integrated approach for water pipe network calibration and quantifying leaks. The approach merges both field measurements and linear programming to pinpoint pipe leaks (physical losses); then applies Genetic Algorithms (GA) to identify faulty meters and meter thefts (apparent losses). Besides; throughout the process, GIS is used for input data integration and output representation.

Zahid Khan 2023 et.al. This paper presents a method for determining locations in the WDNs that are vulnerable to leakage by combining six leakage-conditioning factors using logistic regression and vulnerability analysis. The proposed model considered three fixed physical factors (pipe length per junction, number of fittings per length, and pipe friction factor) and three varying operational aspects (drop in pressure, decrease in flow, and variations in chlorine levels).

Rangsarit Vanijjirattikhan et. Al. The paper evaluates an AI-based water leak detection system with cloud information management. The main purpose of this work is to systematically collect and manage leakage sounds and generate a classification model. This system is designed to support the leakage pinpointing task by providing newly trained operators with guidance in making decision and to minimize the imprecision due to fatigue.

3. METHODOLOGY:

- Conduct a systematic literature review to gather relevant information on NRW and leak detection technologies.
- Utilize case study analysis to understand real-world implementations and outcomes.
- Engage with stakeholders, including water authorities, government officials, and community representatives, to gather perspectives on NRW management.

3.1 Case Study Analysis:

- Objective: To examine real-world applications and outcomes of NRW reduction strategies and leak detection technologies.
- Approach: Select multiple case studies from diverse regions in India where successful NRW reduction initiatives have been implemented.
- Criteria for Selection: Prioritize cases with detailed information on implemented technologies, community involvement, policy frameworks, and achieved outcomes.
- Stakeholder Engagement: To gather perspectives from relevant stakeholders, including government authorities, water utilities, and community representatives.
  Conduct interviews, focus group discussions, and surveys to collect qualitative data on experiences, challenges, and successes in NRW management.
- Sampling: Employ purposive sampling to ensure representation from different stakeholder groups in the water supply sector.
- Technological Evaluation: To assess the effectiveness of existing leak detection technologies in Indian water supply pipelines. Evaluate the performance, cost-effectiveness, and adaptability of advanced sensors, acoustic monitoring systems, and satellite-based technologies.
- Benchmarking: Compare the technological solutions against international best practices and standards.
- Policy and Regulatory Analysis: To understand the role of government policies and regulatory frameworks in addressing NRW in India.
  Analyze existing water supply policies and regulations at the national and state levels. Evaluate their alignment with local conditions and their impact on NRW reduction.
- Documentation: Collect relevant documents, policy reports, and legal frameworks to inform the analysis.
- Community Engagement Assessment:

To explore the importance of community engagement in NRW reduction efforts.
Examine case studies and literature highlighting successful community-driven initiatives. Evaluate the impact of awareness campaigns, education programs, and participatory approaches.

3.2Methodology Adopted

Water Auditing : Two portable ultrasonic flow meters shall be deployed on either end of transmission mains of known length to measure the quantity of water flowing in the main for a period of 24 hrs at the interval of one hour or so. The difference between two readings gives quantum of the lockage in the main Maximum 2 to 3% losses is acceptable in the transmission main the main must be of homogeneous material like C1, Steel, ACC, and PVC. Flow in PSC pipes cannot be measured by this USFM. It is important that the pipe should run full free from turbulence

District Metering : Divide the network into separate district of conveyance size to which supply is affected through one or more bulk water. Ideally each district shall have about 5000 connection and each district shall be isolated by providing sluice Valve. Meter in the district should read flow without excessive loss of pressure. Regular monitoring shall be done for 24 hrs period or during night hours. In order to have effective control leak detection and logical testing, district metering is contemplated after completion of rectification work.

Bulk Water Metering: Bulk water meter (Mechanical Type) may be fixed in the outlet of clear water tank of WTP or outlet of Service reservoir to evaluate total quantity of water supplied per day to the town D/F bulk water meter may be of 300mm Dia or so with tapers on either side, if the main is bigger than the meter. Alternately ultrasonic flow recorder (fixed type) or ultrasonic flow recorder (insertion type) may also be erected in the above outlet points.

3.3 Non-Revenue Water (NRW) - Chittorgarh & Unaccounted for Water (UFW)

Non-Revenue Water (NRW)

Definition of Non-Revenue Water (NRW)

In a fully metered system, revenue is derived from charges for the total quantity of water recorded by consumer's meters. All other water produced and not told in this way is referred to as "Non-Revenue Water". It includes

- Unmetered water supplied to government, or for other public purposes
- Water supplied through illegal connections
- Water supplied to the consumer but not recorded by the meter or included in the meter reader's record. This may include relatively low-rate flows from underground leaks or dripping taps in consumer's plumbing system that will not register on the meter when there is no other draw-off, even if the meter is in mint condition.
- Water supplied to the consumer but not recorded because of defective metering

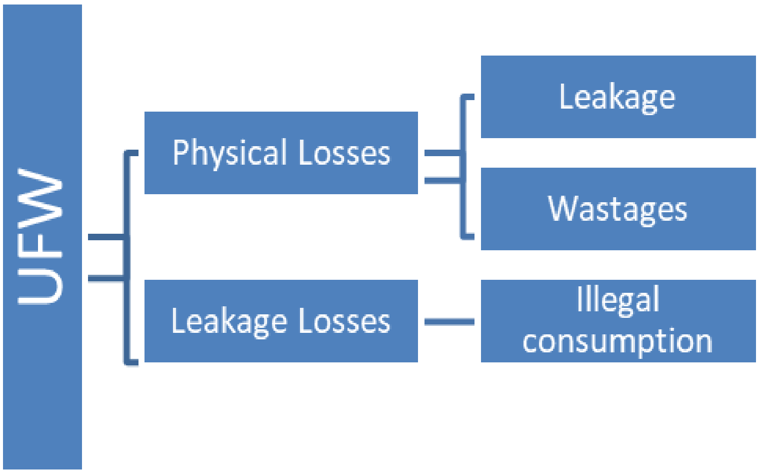

Fig 1: Representation of Unaccounted for Water

4.Experimental Work

The main vision is to optimize social and economic development in urban City and other area of state. The vision will be achieved through policy reforms to strengthen urban management and support for priority investments in urban infrastructure and service required to meet basic human needs, improve quality of life, and stimulate sustainable economic development. The main purpose

- Redress immediate infrastructure and service deficiencies to meet basic service delivery norms;
- act as a medium through which policy reforms are effectively executed;
- provide maximum demonstration effect for replication in other cities of the state Rajasthan Urban Sector Development Investment Program (RUIDP) of Rajasthan, the following town (Chittorgarh) have been taken to strengthen the infrastructures.

City Profile: The Chittorgarh town is situated in the North-West of Aravali Mountains which is in the western part of Malwa Plains. The southern part of the land of Chittorgarh is very rich from the point of view of Agriculture and mineral resources. Chittorgarh has hilly character and soil is dark coloured soil having silt. The population of the town is 121449.

Demography

The table shown below briefs about the city economical details:

Table 1: City economical details

Particulars	Details
Geographical Area	30.50 Sq.km
District	Chittorgarh
Number of wards	35
Total Population (2021)	131600
Total no of Households	14897
Density of population persons per sq.km.	6300

4.1 Present status of water supply in town:

Water supply: the present water supply infrastructure in Chittorgarh is inadequate for the needs of the growing population. The per capita water supply levels give an indication of the quantity of water supplied. It does not indicate issues such as seasonal variation in supply levels.

The major source of drinking water for Chittorgarh is river Gambhiri, which flows right through the habitation of the town.

Table 2: Number of Connections for Water Supply at Chittorgarh.

S No.	Use of Water	Connections
1	Residential	10584
2	Commercial	128
3	Municipal	0
4	State Government	71
5	Central Government (Non-commercial Connection)	28
6	Industrial	15
7	Stand Post	37
Total Water Supply		10863

The per capita water supply of the town is about 95 lpcd, which is merely adequate and as per the recently sanction reorganization water supply scheme of Chittorgarh, it would be up to 135 lped in the next 15 years.

4.2 Pure Water Transmission Main & Allied Works

The treated water is fed into a sump located near treatment plant. The pure water is pumped through gravity directly into OHT, located at various places in the city.

Service Reservoirs & Distribution System

Reduction of non-revenue water will involve:

Replacement of non-functional water meters

Repair of house connections

New Bulk meters to be installed on rising main and distribution main from SR

4.3 Existing distribution system and Salient features of present water supply system in Chittorgarh:

Therefore, the rate of supply has been taken as 135 Liters per capita per day. As per guide line given in circular No. 3 of RUSIDP 15% distribution losses and 5% transmission losses have also been considered while designing the source. Accordingly, the total demand of water for the town works out as follows:

YEAR	POPULATION CONSIDERED	DEMAND IN LPCD
2021	121449	16395615.0

4.5 Need for the project to improve existing water supply

Due to rapid growth in population, the existing rate of water supply for the town Chittorgarh is less than the national norms of 135 LPCD for a town of this size and status. In general, water supply system for Chittorgarh city is suffering from the following key deficiencies:

- Shortage of water production
- Inadequate ground water recharge
- Decentralized and localized distribution system
- High system losses
- Low pressure in the distribution system.
- Inadequate coverage and complete lack of flow measurement at all ends
- In efficient and old pumping machineries resulting in high operation cost.
- Poor treatment of water supply
- High leakage in consumer connection lines and lack of proper connection system to households resulting in leakage and frequent road cutting

4.6 Distribution System

The physical losses in the distribution system of the town will be assessed by conducting leak deduction study in a street of 50 houses. Such a study would be conducted at four different places in the existing distribution system which will be representative of leakage in the entire distribution system of Chittorgarh.

The non-physical losses in the system will be assessed based on the analysis of secondary data. This loss will be the difference between the water supplied and the bill raised. The mandatory metered service connection will be one of the options to reduce the unaccounted-for water.

Provision of Electro Magnetic Flow Meter

There is no water supply flow meter for the measurement of water supply flow. Provision has been taken for Bulk metering at every Head works in the town. The details of the flow meter are mentioned at the end.

Population Density

The city along with the contiguous residential settlements has a population density 4000 persons per SqKm as per census of year 2011 and is categorized as high-density areas.

Water Supply

The per capita water supply levels give an indication of the quantity of water supplied. The storage capacity available is expressed as a percentage of the total quantity of water supplied per day. This indicator helps to determine the number of times the tank /reservoir needs to be filled, to meet the water demand and to time staggered supply for maximum and equitable water supply to the entire town. This also indicates the standby capacity available in case of emergency and also helps in estimating pumping machinery and power requirement.

Water Supply-Connection-. Water is supplied through 10863 water connections. The most connections are metered.

Table 3: Registered Water Supply Connections

Type	Connections
Domestic – Metered	10584
Commercial	128
State Government	71
Central Govt. (Non-Commercial)	28
Industrial	15
Stand Post and others	37
Total	10863

1. The water supply for the town is supplied during the morning only ie 1 to 1.5 hour per day. The per capita water supply of the town is about 95 lpcd, which is merely adequate and as per the recently sanctioned reorganization water supply scheme of Chittorgarh, it would be up to 135 lpcd.
2. The quality of water supply through Gambhiri River and tube wells is acceptable. A total number of legal water connections in Chittorgarh is 10863. Though the minimum norm is recommended as 135 lpcd by the CPHEEO, 20% transmission and distribution losses of the system, the total per capita levels work out to be 169 1pcd. Institutions, Management, and Capacity
As per the Circular and norms laid down in CPHEEO rate of water supply is taken as 135 1pcd at the consumer end.
In general, water supply system for Chittorgarh city suffers from the following key deficiencies:
(1) Shortage of water production;
(ii) Decentralized and localized distribution system;
(iii) High operations and maintenance costs due to excessive pumping requirements and a decentralized system;
(iv) High system losses,
(v) Low pressures in the distribution system due to inadequacy of storage capacity;
(vi) Inadequate coverage and complete lack of flow measurement at all ends;
(vii) Inefficient and old pumping machinery resulting in high operating costs;
(viii) High leakages in consumer connection lines and lack of proper connection system to households resulting in leakages and frequent road cuttings.

5. RESULTS AND DISCUSSIONS

The water supply improvements aim at improving supply levels to the citizens based the following: immediate rehabilitation of the system to address system deficiencies mentioned previously, and subsequent long-term program of leak detection and rectification, improving the quality and quantity of water supplied at consumer-end through source augmentation, improvements to water treatment facilities and real time monitoring of the distribution system for technical losses, water theft and indiscriminate usage of water at public standposts; providing universal connections and metering; providing 135 lpcd (net supply) water to the population, reducing the O&M costs of water supply system through energy conservation, improved efficiency and monitoring of water flows, and improving duration and frequency of water supply through effective water demand management.

Alternative Proposals for Replacement of Corroded Mains:

A. General

International practice is now to use MDPE rather than the traditional CL, as this material has been developed

B. Advantages Offered by Mdpe

Advancement in materials used in water industry has seen the evolution of Medium Density Poly Ethylene (MDPE). MDPE has been in service for a very long time in most European and South east Asian countries and are known to be functioning without major complaints. MDPE has a high degree of resistance against corrosion both on inner and outer surfaces

- MDPE offers a very high 'C' Value of 130-140 resulting in lesser friction and corresponding conservation of pressures in the system.
- Life of MDPE is known to be greater than fifty years.
- MDPE pipes possess a high degree of impact strength and toughness coupled with flexibility which permit easy laying
- MDPE pipes (100 mm/150 mm) can be procured in rolls of 25 or 50 metres. This allows laying of continuous pipe with lesser number of joints. This reduced number of joints is advantageous in conservation of water.

- The joints on MDPE are fusion welded butt type which ensure homogeneous and continuous pipe shell thereby giving no room for leakages. This is not the case in CI pipes where either lead or rubber rings are used for joints which is different from parent material.

C. Laying and Jointing of MDPE Pipes

As mentioned earlier, MDPE distribution mains (110/160 mm) can be procured in rolls of up to 50 m length which means continuous pipes without any joints. This implies that a street of length 150-200 m can be covered with a maximum of 4-5 joints. The fusion welded butt joints can be easily made at site using simple jack and mirror heating element. In fact the joints can be made above ground prior to lowering the pipe.

D. Providing House Service Connection on Mdpe Distribution Main

It is extremely easy to provide MDPE house service connections of 20/25/32 mm on the MDPE distribution mains (110/160 mm) using saddles with neoprene gasket.

E. Availability of MDPE Distribution Mains (110/160 Mm) In India

The MDPE material and pipes which strictly conform to the Health Standards laid down by WHO are manufactured in India by at least three reputed companies each of which is confident of meeting demand. These companies manufacture pipes conforming to ISO standards and by using high quality imported extrusion machines with stringent quality.

Water Supply – Chittorgarh:

In general, water supply system for Chittorgarh city suffers from the following key deficiencies:

(i) Shortage of water production
(ii) Dependence on groundwater resources
(iii) Inadequate groundwater recharge
(iv) Decentralized and localized distribution system
(v) High operations and maintenance costs due to excessive pumping requirements and decentralized system
(vi) High system losses
(vii) Low pressures in the distribution system due to inadequacy of storage capacity
(viii) Inadequate coverage and complete lack of flow measurement at all ends
(ix) Inefficient and old pumping machineries resulting in high operation costs
(x) Poor treatment of water supply
(xi) High leakages in consumer connection lines and lack of proper connection system to households resulting in leakages and frequent road cuttings
(xii) Meter system for billing needs to be introduced

The water supply improvements aim is to improve the supply levels to the citizens based on the rates of water supply at 135 LPCD as recommended in the CPHEEO manual with 20%

Water Auditing

Two portable ultrasonic flow meters shall be deployed on either end of transmission mains of known length to measure the quantity of water flowing in the main for a period of 24 hrs atthe interval of one hour or so. The difference between two readings gives quantum of the leakage in the main. Maximum 2 to 3% losses is acceptable in the transmission main The main must be of homogeneous material like CL, Steel, ACC, and PVC. Flow in PSC pipes cannot be measured by this USFM It is important that the pipe should run full free from turbulence

District Metering

Divide the network into separate district of conveyance size to which supply is affected through one or more bulk water. Ideally each district shall have about 5000 connection and each district shall be isolated by providing sluice Valve. Meter in the district should read flow without excessive loss of pressure. Regular monitoring shall be done for 24 hrs period or during night hours. In order to have effective control leak detection and logical testing. District metering is contemplated after completion of rectification work.

PHD engineers shall select small or compact district to maintain required pressure and to locate district metering pevoramely In tellotar of pavement district metering shall be utilized for periodical leak detection & rectification program for water supply engineers.

Bulk Water Metering

D/F bulk water meter may be of 300mm dia or so with tapers on either side, if the main is bigger than the meter.

Bulk water meter (Mechanical Type) may be fixed in the outlet of clear water tank of WTP or outlet of Service reservoir to evaluate total quantity of water supplied per day to the town.

Alternately ultrasonic flow recorder (fixed type) or ultrasonic flow recorder (insertion type) may also be erected in the above outlet points. If the size of main is larger than 300mm to 1200mm, elastic magnetic flow recorder shall be installed in the main with a pressure of 10D up steam side and 5D into D/S end. The meter is of course costly but gives reading with an accuracy of (+/-) 1%. The meter does not have any moving parts hence trouble free.

Table 4: NRW Expert data sheet.

	NRW EXPERT	
1	Name of ULB	Chittorgarh
2	Normal Pressure	0.5Kg/cmSq
3	Normal flow	100 KLD
4	Water supply distribution hours	1.0 Hours/day
5	Number of house service connections	12022
6	Water meter provided	100%
7	Water meter not provided	NIL
8	Number of stand post and water quantity supplying approximately	37 and 9 MLD
9	Number of sluice valve & chambers	SV-72, SUC-18
10	Existing main	AC/CI
11	Time of water supply to public	6 AM to7.30 AM
12	Length of pumping main	AC 45KM + CI 20 KM-65Km(3” to12”)
13	Length of distribution main	AC 90KM + CI 20 KM1=10Km(3” to20”)
14	Total number of Houses	20,000
15	Per connection PHD rate	Rs.30 for Domestic
16	Commercial	0 KLD of water
17	Non-Domestic	130 KLD of Qty. water
18	Other Commercial (industrial)	20 KLD of Qty water
19	Number of GLSR (or) OHT	15 OHSL, 12 CWR
20	Average loss in Percentage	35%
21	Number of Public fountain	Single
22	Total Revenue Assessment per year	Rs. 42.69 Lacks

(b) Calculation – Loss of water and NRW Chittorgarh

- Total Production of water = 10200 KLD
- Less 25% Losses in raising main = 2550 KL
- Actual supply to the town (10200-2550) = 7650 KLD
- Less 15% Loss in distribution system= 1147.5KLD
- Actual water brings supplied to the consumers = 6502.5 KLD

- Loss of water= 10200-6502.5 = 3697.5 KLD

(3697.5×100)/ 10200 = 36.25%

- But Revenue is collected from the consumer on the basis of water supply = 6684.0 KLD
- NRW = 10200-6684 =3516 KLD

(3516×100) / 10200 = 34.47%

Non-Revenue Water (NRW) Chittorgarh & Unaccounted for Water (UFW):

Non-Revenue Water (NRW)

a. Definition of Non-Revenue Water (NRW)

In a fully metered system, revenue is derived from charges for the total quantity of water recorded by consumer's meters. All other water produced and not told in this way is referred to as "Non-Revenue Water". It includes

1. Unmetered water supplied to government, or for other public purposes
2 water supplied through illegal connections
3. water supplied to the consumer but not recorded by the meter or included in the meter reader's record. This may include relatively low rate flows from underground leaks or dripping taps in consumer's plumbing system that will not register on the meter when there is no other draw-off, even if the meter is in mint condition.
4. water supplied to the consumer but not recorded because of defective metering.

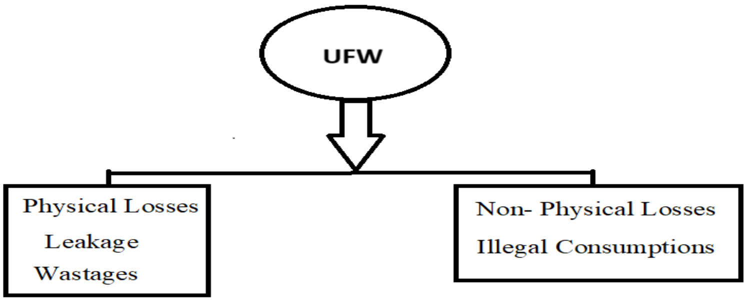

Fig 2: UFW Losses

Definition of Unaccounted for Water (UFW)

The term "unaccounted-for water" (UFW) is self-explanatory. It represents the difference between "net production" (the volume of water delivered into a network) and "consumption" (the volume of water that can be accounted for by legitimate consumption, whether metered or not). The definition is simple, but determining the true figure can be difficult

Source Improvement

1. The existing sources to cater to the ultimate demand with regard to catchments, hydrological details, reliability, dependability, accessibility, quality, and the sources of pollution etc.

2. The new potential sources for water in co-ordination with various other departments to cater for ultimate demand (2041) if the existing source is deficient with regard to catchments, hydrological details, reliability, dependability, accessibility, quality and the sources of pollution etc.

Flow Meters Used

The DIGISONIC-P flow meters manufactured by Ultraluxe (France) (Model DIGISONIC-P) used for the flow measurement

Procedure – Leak Detection

a) Identifying the quantum of unaccounted for water (UFW), within the acceptable levels and to train the corporation staff.

b) Prepare a justified plan in repair, replacement, strengthening and rehabilitation and expansion of water supply system.
c) Testing both mains and service line to ensure to 15 l/c/h.

Method of Working

For this project, the following actions have been proposed.
a) Mains Condition survey to be carried out by removing 1.0 meter sections of main at 11pprox. of main at 11pprox. 1.50 m. intervals to examine pipe condition Mains in poor conditions to be reported to Corporation for replacement.
b) Test length will be on an average of 200 meters to improve test result by improve test results by improving leak location ability.
On completion of the above work the final testing of mains and services to the boundary stop tap (if available) can be completed

Procedure suggested

1) Cut mains to install injection points and isolating valves – check condition of mains. If in good condition, install valves, etc. If bad, report to corporation for renewal.
2) Test mains and services to boundary by raising pressure to ml. locate and repair any leakage. Target to be aimed at is 15 l/c/hr.
Any significant leakage above this level would indicate that services have probably failed under pressure. Therefore, these existing services should ideally be left open at the ferrule points and stop tap to sound for leakage. Any leaking services should be rectified and the test repeated.

Details of work involved

The work to be undertaken falls in to two categories.
a) Installation of valves and test points on mains for testing purposes and carrying out up to 150 mm dia.
b) Carrying leak test at 10 meters head and the target leak is at 151/c/hr.

Design Parameters:

They shall be confirming to manual water supply and water treatment (CPHEEO).

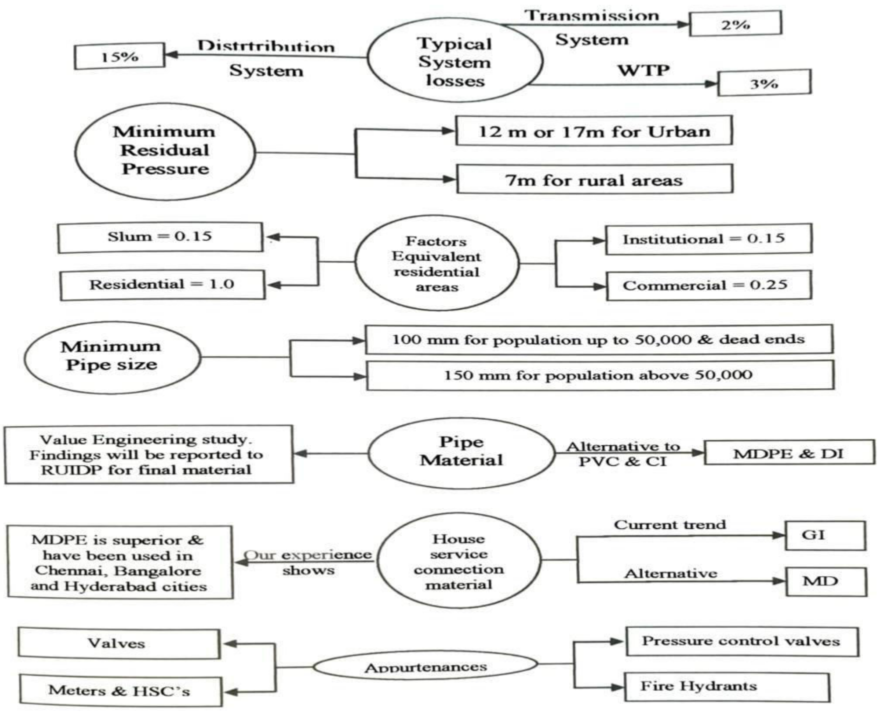

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Fig 3: Design Parameters

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Table 5: Proposed design parameters.

1.	Distribution system losses	15%
2.	Minimum residual pressure	12 m in general. However, few nodes in a Zone having higher elevations may have lower residual head
3.	Class of Pipe	The pressure class of pipe shall be decided based on the static pressure at ground level with respect to the service reservoir full supply level.
4.	House service connections	MDPE pipes
5	Valves in the network shall be provided in such a way that small areas in the loop could be isolated for any repairs required.	
6	Pressure reducing valves will be proposed where residual pressure over service reservoir is exceeding 5m to have proper control over the flow to reservoir.	
7	Meter on the service reservoir out let shall be proposed to measure the zone flow.	
8	Fire hydrants shall be proposed at the rate of one hydrant for 15000 population duly considering existing fire hydrants.	
9	Stand posts shall be restricted to 5% of intermediate stage population, year 2024, duly taking in to account the existing.	
10	Hazen William formula shall be used for working out the frictional head loss in the network with 'C' Values as specified in the DPHEEO Manual for new pipes and the 'C' values for existing pipes shall be decided in consultation with PHED. Other losses at 10% of frictional head loss shall be considered.	
11	The distribution network shall be designed with peak factor of 3 as distribution zones are small.	
12	We propose that distribution mains of diameter 350mm and above shall be treated as conveyance mains and no service connections shall be provided on these mains. Pipeline of smaller size as per the requirement shall be proposed in parallel to the conveyance main for the service connections. Existing smaller size distribution line. If available here. Shall work as service line in such cases.	

Switch over from intermittent supply to 24x7 supplies is proposed in the year 2016, 7 years after commissioning. During the intermittent supply, the supply hours shall be 3 hours in the morning and 3 hours in the evening. The network shall be checked for the intermittent supply with peak factor of 4 for the demand in the year 2016 UFW/NRW are also be taken about.

6.Conclusions

Non-Revenue Water (NRW) is a significant challenge in water supply systems, representing the portion of water that is lost before reaching consumers or generating revenue. Efficient leak detection plays a crucial role in addressing NRW and ensuring the sustainability of water supply pipelines. By identifying and repairing leaks promptly, water utilities can minimize losses, conserve valuable water resources, and enhance the overall efficiency of their systems. Leak detection technologies, ranging from traditional methods to advanced technologies like acoustic sensors, pressure sensors, and data analytics, provide water management authorities with effective tools to pinpoint and address leaks in a timely manner. These technologies not only contribute to water conservation but also improve the financial viability of water utilities by reducing operational costs and increasing revenue. Investing in comprehensive leak detection programs, coupled with

regular maintenance and infrastructure upgrades, is essential for minimizing NRW and ensuring the long-term resilience of water supply systems. Additionally, public awareness and community involvement are crucial in fostering a culture of water conservation and responsible water usage.
In the face of growing water scarcity challenges, the combination of advanced leak detection technologies, proactive maintenance strategies, and community engagement represents a holistic approach toward sustainable water management. As technology continues to evolve, ongoing research and innovation will further enhance our ability to detect and address leaks efficiently, ultimately contributing to the preservation of one of our most vital resources – water.

Future Scope:

After completion of comprehensive leak detection study and equitable water distribution studies, the deficiency in the network will be identified to achieve the 24X7 in the network with objective given below. The performance-based investment plan will be prepared to upgrade the system and the emphasis will be given for stetting the benchmark for the water supply status in distribution.

- Unaccounted for Water (UFW) Level within target level, will be decided for each distribution zone.
- Water Quality & Reliability of supply
- Consumer Service & Complaint management
- Improved meter reading and billing system
- Increase in revenue water

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