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# A REVIEW PAPER ON JALTANTRA: A SOFTWARE USED FOR OPTIMIZATION OF WATER DISTRIBUTION IN UNDERDEVELOPED AREAS

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**Abstract -** *Designing a water distribution system necessitates balancing various factors, and accommodating large investments to manage both future and current water demands while focusing on fixed budget constraints. However, the manual design process often results in overwhelming due to the huge volume of work involved. Understanding this challenge, developing an innovative water distribution system became essential. Many existing systems are either outdated or financially unfeasible. Consequently, Jaltantra, an open technology platform, was created by scholars from IIT Bombay collaborating with engineers from Maharashtra Jeevan Pradhikaran (MJP). The software aims for holistic adoption in academia as well as government sectors. Jaltantra`s algorithm for optimization takes into account pipe and energy costs, with future iterations set to involve GIS-based demand allocations and various data visualization techniques. This review paper assesses Jaltantra`s capabilities through a detailed study of numerous research papers, highlighting its efficacy in optimizing water distribution systems efficiently.*

***Key Words***: **Jaltantra, water distribution system, Maharashtra Jeevan Pradhikaran, pipe diameter, cost optimization, water demand.**

## 1.INTRODUCTION

Government bodies in India face a redoubtable challenge; ensuring citizens receive high-quality drinking water while adhering to budget constraints. This dilemma often leaves engineers grappling with inadequate tools that prioritize pipe diameter selection but overlook other crucial elements of the water distribution system. Consequently, much of the design process relies on impromptu methods or the engineer`s intuition. To address this issue, Jaltnatra was developed to aid government engineers in determining various components of water networks, such as tanks, pumps, valves, and pipe diameters. By implementing an integer linear program model, Jaltantra delivers optimized, efficient and streamlined design processes ensuring accurate results. The engineers of Maharashtra Jeevan Pradhikaran (MJP), were tasked with developing multi-village piped water distribution in Maharashtra. With a workforce exceeding 1500 engineers, the MJP faces complex decision-making processes that significantly impact project costs. Overseeing the design of more than 11,000 rural water distribution schemes, the MJP aligns each design with government-mandated budgets to ensure affordability and service quality. Traditionally, gravity-fed branched networks are favoured over cyclic networks due to their cost-effectiveness and the unreliability of electricity supply. Despite decades of research on cost optimization, existing software tools like BRANCH, EPANET, and WaterGEMS primarily focus on pipe diameter selection, often neglecting critical components. Jaltantra addresses this limitation by enhancing cost optimization for pipes and tanks, with ongoing improvements aimed at incorporating pumps and valves while considering both capital and operational costs.

## 2. REVIEW OF MODELLING SOFTWARE

The Jaltantra software Integrates multiple aspects of network designing including important parameters like geographic data population distribution and water demand while adding constraints such as budget limitations and terrain characteristics. By using sophisticated optimization algorithms like integrated linear programming Jaltantra processes this data to find optimal solutions considering factors like pipe diameter pump locations and storage time capacities to reduce cost while aligning with the specified requirements such as budget constraints. Its significant advantage lies in the capacity to heuristically optimise cost factoring in the capital and energy costs associated with the infrastructure. By carefully selecting the optimal design alternatives and providing the intuitive visualization and analysis tool Jaltantra helps engineers and planners in developing a very efficient water distribution network its feature helps sustainability promote enhanced efficiency and offers a user-friendly interface contributing to improved water management practises in long-term sustainability.

## 3. LITERATURE REVIEW

***1***. ***Dr. G. Venkata Ramana, et al. (2015***): This paper concentrates on optimising water distribution in Chowdhuru Andhra Pradesh using EPANET. The methodology Methodology includes creating a design based on collected or available data extracting the network layout from Autocad EPANET, and calculating the total demand from a reservoir through hydraulic scheme design. Ethernet is used effectively aiming to enhance the efficiency of the rural water distribution system noting the specific needs of the YSR Kadapa district in Andhra Pradesh the methodology included analysing the distribution network which consisted of 50 three pipes of the same material with 49 junctions one tank and one source reservoir from which water is produced to the elevated reservoir the residual pressure at all the nodes was observed to be greater than 7.00 metre making the flow easier the internal diameter was assumed of 6 3.50 mm To be sufficient to bear the pressure for the entire network. Design network could also withstand for 5% increase in population instead of 1%.

***2***. ***Mr. Mominah Ajaz, et al (2023)***: This study optimises the water distribution system (WDS) at the University of Kashmir in Hazratbhul India using a quantitative approach and various software tools. The study involves data collection on campus population and groundwater depth and employs EPANET for hydraulic modelling to enhance the WDS efficiency this study proposes an optimal replacement design for the University of Kashmir's outdated water distribution system serving for over 60 years. The design prioritises a study of 17-metre pressure heads at all nodes eliminating the need for pressure walls and reducing costs it maintains safe flow velocities in pipes and assesses system performance via the Total performance index (TPI). Cost optimization is achieved through minor pipe diameter adjustments.

***3. Ms. Ashwini Gajbhiye, et al. (2017)*** : The paper represents the different methods of league detection and the advantages of using EPANET for leak modelling. The methodology is that they create a hydraulic model of the water distribution system using EPANET next they estimate the background leakage rate for the system finally they add leaks to the model at different locations and sizes and stimulate and simulate the system to determine the impact of the leaks on the water supply and distribution. They found that the background leakage rate for the system was 10%. They also found that the addition of leaks to the system can significantly reduce the water supply and increase the pressure fluctuations in the system. The hydraulic modelling of the study area's water distribution system using EPANET was successful and validated using real-time pressure data demonstrating that the system operated under significant pressure however EPANET couldn't independently model leakages resulting in the identification of 10 high-probability leakage points. The model struggled to simulate 40% leakage leading to negative pressure and inability to operate for 24 hours the system's allowable leakage percentage using water distribution was determined to be 10%.

***4. Ms. Mohini M. Dumane,et al. (2018):*** The methodology involves the systematic analysis of methods and principles in a field providing a theoretical foundation for selecting suitable methods or breast practises in specific cases not necessarily offering solutions this project addresses global water scarcity aiming to enhance water supply efficiency reduce leakage improve maintenance and optimise costs in existing water supply current study aims to create to create an efficient water distribution network for the barcode region it was identified that the existing storage capacity of the ESR in Wageshwar is inadequate. This issue and to meet the water demand of the Bakori region a new water distribution network is proposed. The plan is ready for implementation to ensure effective water distribution with ample pressure.

***5. Ms. G. Anisha, et al. (2016):*** Designing water supply and sanitation schemes requires accurate population projections considering factors like births, deaths, migration and annexation various methods like arithmetical increase and masterplan approach in population forecasting. Water demand types include domestic, industrial, institutional, commercial, public use, fire demand and loss compensation. Systems can be gravity pumping or dual with layouts like dead-end gardens circular or radial water supply can be continuous or intermittent EPANET is a computer model analysis of water distribution networks calculating flow rates and hydraulic grade lines at nodes. The current distribution network in Chirala municipality, Comprising five zones is insufficient for future demands 2041. the existing capacity of 15 .44 MLD falls short for the required 19.08 MLD . To address this two 2 MLD reservoirs are proposed to supplement demand. Network alliance with the town's future expansion and includes two additional zones for reservoir constructions.

***6. Mr. Athulya T. ,et al. (2020):***This study area Anjana Khandi Grammar Panchayat is in Kundur Kerala it covers 15.36 square kilometres and includes parts of Anjarakhandi and Panayathamparamba. The water distribution network was modelled using Google Earth and EPANET. Nine factors like pipe layout diameter and roughness were considered unpopulation forecasting was used for demand estimation. The Hardy Cross method was applied to optimise flow within a loop the water distribution network in Anjarkandi Grama Panchayat, Kerala was successfully designed and analysed using Epanet Software and the Hardy Cross method incorporates a combined gravity and pumping system ensuring inadequate pressure and slow through the network. The efficiency and accuracy of EPANET make it preferable over manual methods like Hardy Cross especially for large scale networks prompting the Kerala Water Authority to adopt it as the recommended tool for water distribution system design.

***7. Mr. R. R. Bhosale, et al. (2022):*** Kusgaon PM Village located in Pune District India experiences an elevation of 612 metres above MSR with an average temperature ranging from 18 degrees Celsius to 33 degrees Celsius. Open flows water gems software aids in infrastructure planning providing tools for system reliability optimised operation and asset renewal decisions. Population growth is projected using a 4.56% growth rate with demand calculations indicating sufficient storage capacity. The methodology involves area selection data collection analysis software modelling and design. The project's primary objective was to create a water distribution network. Although the reservoir`s capacity was adequate a new distribution network was required. Challenges encountered during modelling included data input accuracy and defining project-specific output requirements. Ultimately the model was optimised for cost effectiveness.

***8. Mr. Rai, et al. (2017):*** The Hardy Cross method for looped network analysis involves several steps. Initially, nodes and pipe links are numbered and continuity equations are applied to calculate initial pipe discharges, calculating key values and applying loop discharge corrections the process continues until corrections are within allowable limits or head losses are small. The contrast using EPANET for hydraulic network analysis involves drawing and editing the network specifying operational details running hydraulic analysis and reviewing results the analysis of a 4-loop hydraulic network using the Hardy Cross method revealed that permissible results were achieved in the 4th iteration meeting the criteria of summation $\sum HL \leq 0.150$ metres while acceptable results were attained in the 10th iteration with summation $\sum HL \leq 0.0001$ metres. This study identified fluctuations in pressure heads among the 9 junctions and found that increasing pipe diameter or adding booster pumps could address negative pressure head issues in terms of pipes the study found a close match between actual and Ethernet computed flow rates and head loss values.

***9. Mr. Suryakant I. Jadhav, et al. (2018):***In this paper the relevant data was gathered from Chalisgao Municipal Council. Then they calculated water demand using appropriate methods and proceeded to map to study area using Google Earth subsequently all the collected data was imported into WaterGEMS software leveraging the capabilities of WaterGEMS. Utilised the designer tool to optimise the design of the water distribution network. They conducted simulations within water gems to derive an optimal solution for the pipe distribution network ensuring an efficient and effective water supply system. The research findings indicate several key points. Muslim the census data reveals that the current water demand is insufficient to cater to the existing populations. Delhi Command Transitioning from intermittent to continuous water supply necessities of additional elevated storage reservoirs in the new zones. Zoning the entire city of Chalisgaon into eight zones based on elevation and population density was accomplished. Asleep to ensure continuous water supply it is imperative to replace old pipes in areas where demand is influenced by population growth.

## 4. CRITICAL LITERATURE REVIEW

In summary, these studies presented collectively Imply the pressing need for the overhaul and optimization of ageing water distribution networks to accommodate both current and future demands these investigations reveal several crucial findings such as a requirement for increased storage capacity the importance of fine-tuning pipe diameters and the adoption of sophisticated modelling tools like Epanet, Water GEMS and Jaltantra for precise system design and evaluation. These studies imply the significance of addressing population growth and transitioning from intermittent to uninterrupted water supply often necessitating the construction of additional elevated storage reservoirs in new areas. Successful zoning strategies based on elevation and population density have been implemented to ensure consistent water delivery. Ultimately these findings stress the urgency of proactive planning and investment to create an efficient resilient water distribution system capable of meeting the evolving needs of the communities they serve.

## 5. CONCLUSIONS

1. After conducting this extensive comparative study it became evident that various factors are responsible for the selection of an effective water distribution system software such as the availability of software compatibility user-friendly description and application of optimal methods.

2. As accuracy and precision are of prime importance the speed in calculating the results are also of same importance they are an applications with such capabilities are in demand.

3. As an open-source solution Jaltantra is often more cost-effective than commercial software like Water Gems making it particularly suitable for projects like limited budgets.

4. As an open source solution Jaltantra can be tailored to local needs and conditions making it more suitable for regions with unique water management challenges or specific regulations.

5. Though most of the software have almost every feature which is required to design an optimal water distribution network the free public domain availability is what that makes Jaltantra an inevitable choice.

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