Hydrological Parametric Investigation of Water Distribution Network for Sawale Village, Raigad District (Maharashtra): A GIS Approach

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Abstract

The water distribution network (WDN) is considered one of the most important infrastructural requirements for future cities worldwide. In order to meet the growing water demand of the developing population, it is essential to design a sustainable WDN. In recent decades, numerous researches have been conducted in this field considering various parameters, but poor WDN layout design leads to increasing project cost in terms of execution, maintenance, etc. Hence, the objective of this research work was to overcome the above drawbacks by designing a real time network for a rural emerging village near Rasayani, Maharashtra with the help of Geographical Information System (GIS) and hydraulic simulation using Environmental Protection Agency Network (EPANET). The area of Sawale village is surveyed both physically and using the software. The basic objective of this research is to determine the best possible way in which a given WDS can be optimized to meet the current water demand in Sawale village. EPANET is hydraulic simulation software that can be efficiently used for such purposes. The results show that hydraulic simulation together with the application of GIS helps to create a less time consuming, sustainable and optimized WDN.

Keywords: EPANET, Geographic information system, Analysis, Hydraulic simulation, Water distribution network

1. Introduction

Water supply structures should also meet the basics for open, business, and modern tricks. In any case, the water must meet both quality and sum requirements for the cities of the future [9] Nowadays, commercial computer programmers are available to show the layout of the distribution system and the pipe network, providing comprehensive information about the pipe such as diameter and length [10].EPANET was created by the Water Supply and Water Resources Division of the Water Supply and Water Resources Division of the National Risk Management Research Laboratory of the United States Environmental Protection Agency. It is open regional programming that can be copied without restriction. The basic leadership capabilities, accessible immediately in a single association, make GIS a great instrument for coordinating organizational forms. EPANET is a Windows-based program that enables broader reproduction of water supply and water quality in pressurized pipe systems [14].

2. Literature Review

G. Anisha et al. (2016) is working on a water system in the city of Chirala that may or may not be reliable for years to come. His analysis and design of water distribution networks using EPANET for new supply networks alerts local communities to new requirements and increased demands.

Shivaprasad G.et al. (2017) the research talked about the reconstruction of existing networks and the design of water distribution networks using a programming tool called EPANET that simulates hydraulic and water quality behavior in pressure pipe networks over time. This work demonstrates how his EPANET can be used for hydraulic studies of distribution networks.

Ababu T. Tiruneh et al. (2019) published a paper on the quadratic rate function of the chlorine removal rate, showing that the error between models was between 0% and 15% of his. They suggest extending programs for variable modeling of residual chlorine in distribution networks to improve water quality simulation programs such as EPANET.

Aleksandar Kosarac et al. (2020) Working on the conceptualization of water network planning in transition countries. New water supply concepts that have emerged in transition countries are transforming the approach water suppliers had to take to manage demand in the old system into a system that addresses demand-driven consumption of the water supply system.

Jose Eloim Silva de Macedo et al. (2021) This study discusses a hybrid particle swarm optimization and tabu search algorithm (H-PSOTS) for WDN design. Pure Particle Swarm Optimization (PSO) and H-PSOTS hybrid methods achieved good results in finding the optimal solution and exhibited high computational power, making them a new option for the optimal design of practical water distribution networks.

Nitin Pawar et al. (2022) discuss in their study how to design a water distribution network with desired flow rates and pressures at all ends and with low error. EPANET 2.0 software allows the design of randomly developed domains of varying complexity.

Mominah Ajaz et al. (2023) used the EPANET 2.2 approach to model network water quality and leakage. The objective function of maximum water quality performance efficiency was achieved and minimum percentage of fugitive emissions was verified. EPANET extensions can be used for water safety modeling, real-time modeling, and fire flow analysis.

3. Methodology

The area for which the WDN is designed is the village of Sawale, Taluka - Panvel, Dist.-Raigad, State-Maharashtra. The latitude and longitude coordinates are 118.9054° N, 73.1567° E. Figure 3.1 shows the study area (that is, Sawale village) which originated from GIS. The current water supply system in Sawale village was designed in 1991 in collaboration with HOC company in Rasayani. However, in the current situation, the company HOC has been closed by the government.

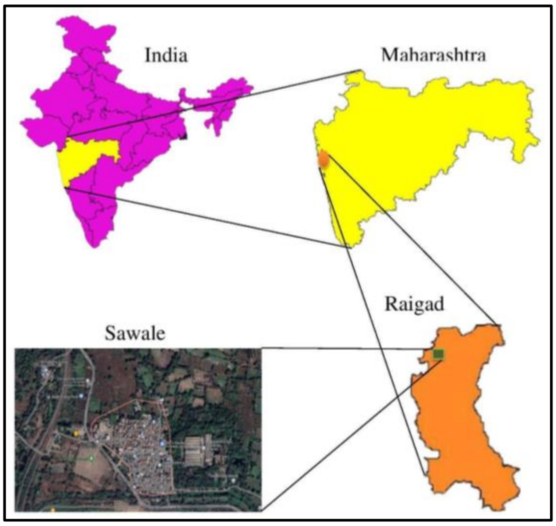


Figure 3.1: Satellite Image of Sawale Village

The existing water supply is provided by MIDC, which is costly and also does not meet the current needs of the village. The pipes used are from the HOC Company and are now buried under various new constructions such as roads, houses, etc. This causes wear and tear on the piping in the current WDN. The basic objective of this study is to determine the best possible way to optimize a given WDN to meet the current water demand in Sawale village. The new WDN will be designed using hydraulic software.

3.1 Objectives

The current WDN of Sawale village in Panvel region was observed, studied and analyzed. Below are some of the other objectives that were addressed in the research

1. To determine the Velocity, Unit Head loss, Friction Factor and Pressure in the Water distribution network.
2. To find out relations between Elevation v/s Pressure, these relations can be understood by studying the graphs plotted.
3. To provide distribution of water for different demands along with adequate or sufficient quantity for Sawale village.

After a radical study of the literature, the right method for the future village is fragmented. The location for which the WDN is designed is the village of Sawale. Step one of the method of a proposed machine includes fact collection. The data is divided into two components: records preparation for the take-a-look-at area and records series for the field examination. The first facts instruction for the observed area includes records consisting of Google and satellite tv for pc imagery, avenue community maps, and land use or insurance .Facts collection for the sector survey consists of population, supply and water tank, pipeline, and node. Those data are gathered from the agricultural Water supply and production branch in Panvel. The following step is to build the community based totally on the observations. This network can be drawn with the use of the EPANET software program. After the community diagram is finished, it'll be materialized in this software. The alternative critical information is always furnished for one of these networks within the hydraulic software program. That critical info is divided into the entries of connections/pipes and nodes/branches. Info of connections/pipes consists of the period, roughness, and diameter of pipes, and details of nodes/branches encompass the elevation of soil and water demand at that node. That is enough to start the EPANET software program with the details furnished. After jogging the network with the given information, the output is analyzed. This analysis document might then offer the answer to the easy however powerful question of whether or not the community is fine or now not. If the analyzed result has a tendency to be unsatisfactory, the supplied information is returned, and the output is analyzed once more. If the analyzed end result is great, the output is extracted within the shape of graphs and tables. Figure 3.2 Shows the flowchart of methodology.

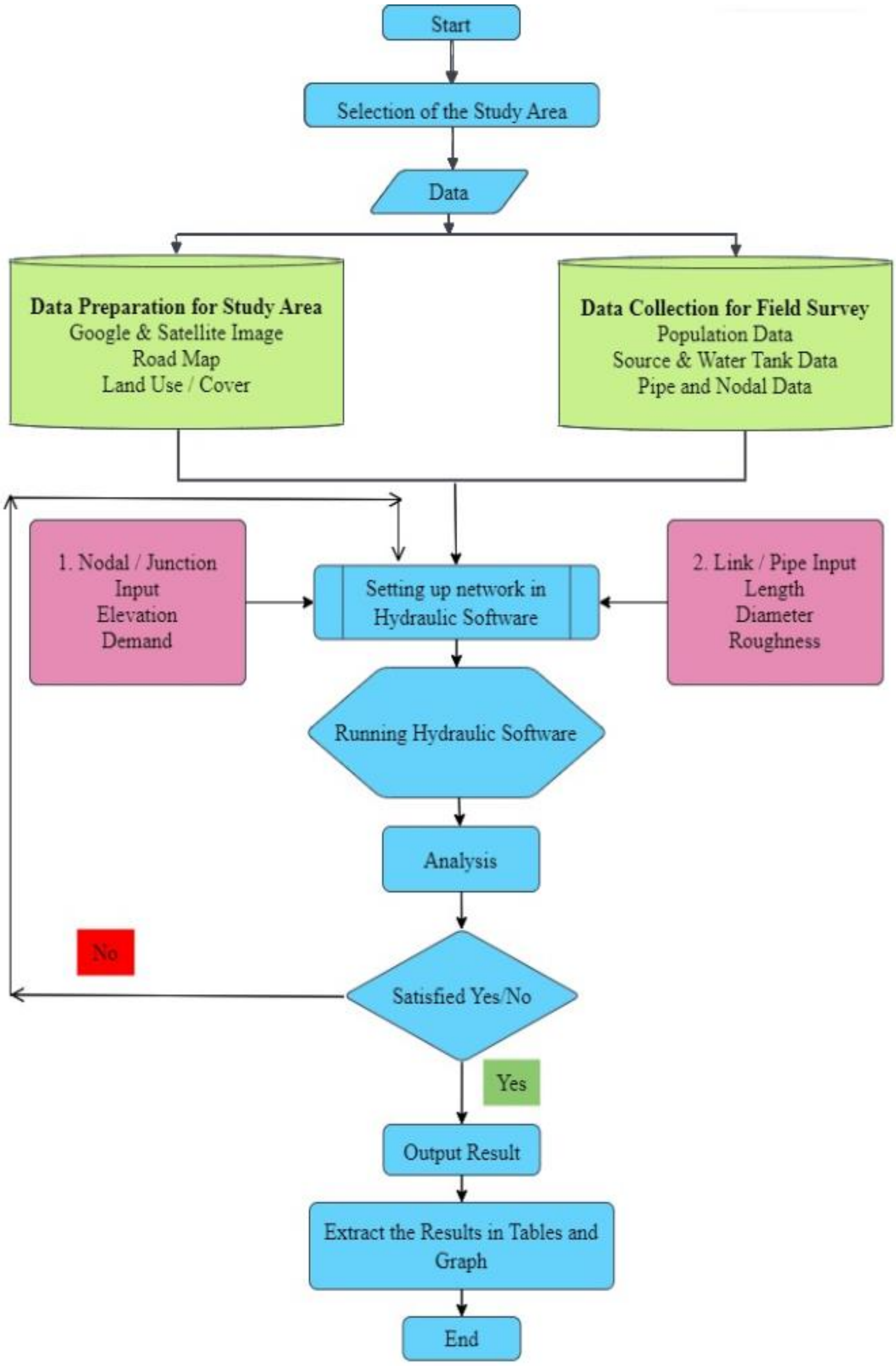


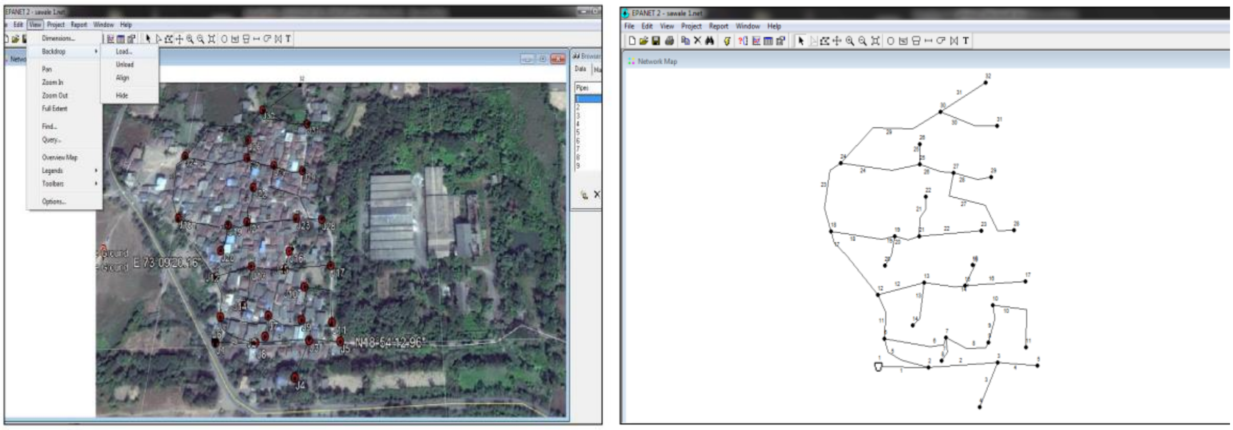
Figure 3.2: Flowchart of Methodology

3.2 Setting up the Network in Software

Different Figures show steps involved in setting up the network using EPANET software. Figure 3.3 shows the relative position of a junction on Google earth image of the corresponding area.

Figure 3.3: Google Earth-image Joint Photographic Experts Group converts to a Bitmap image (Source: URL 12)

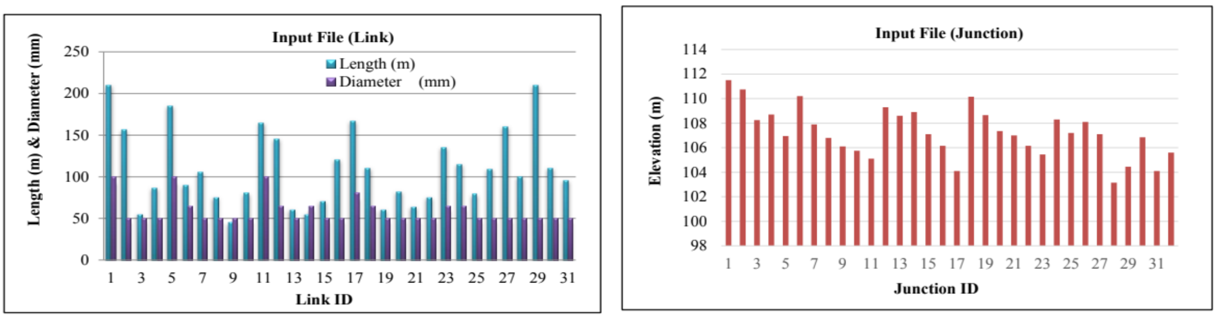
Steps to load and unload Google earth image as a background image in EPANET are shown in Figure 3.4



(a) **(b)**

Figure 3.4: Setting up Network in Software - (a) Load (b) Unload

Different roughness coefficients for different types of pipes. Galvanized Iron (GI) pipe Roughness of link is 120, these pipes are modest, light in weight and simple to deal with and transport and simple to join, therefore use in GI pipe. Following Figure 3.5 (a) shows various data like length and diameter and Figure 3.5 (b) shows data of junction like the elevation to be given as input to hydraulic software.

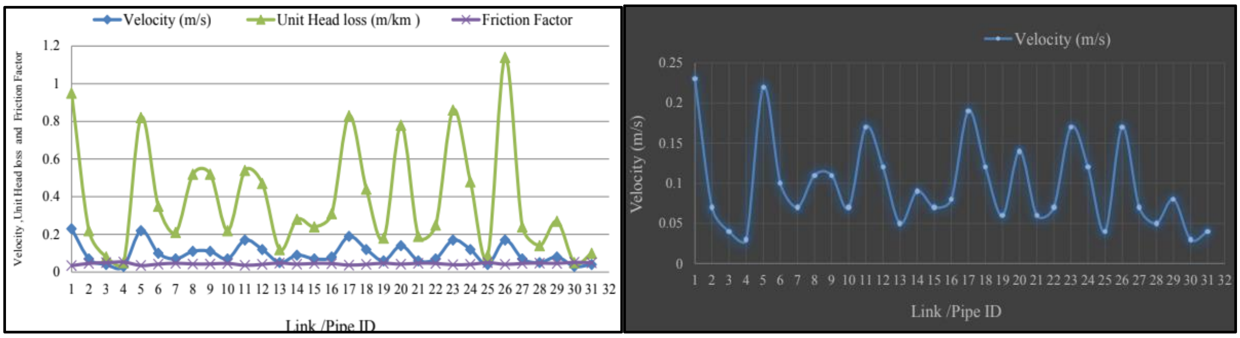


(a) (b)

Figure 3.5: Input File - (a) Link (b) Junction

3.3 Results and Discussions

Data report of links in pipeline network obtained in hydraulic software. This data report shows value given as input as well as some of the calculated values such as flow, velocity etc. same shows data report of nodes in pipeline network obtained in hydraulic software. This data report shows values given as input as well as some calculated values which include head, pressure etc. their result work obtained in tabulate format. Output values like Velocity, Unit Head loss and Friction Factor obtained for various links shown in Figure 3.6 (a).



(a) (b)

Figure 3.6: Results (a) Link Results (b) Results of Velocity in Pipe

The results for the velocity are shown in Figure 3.6 (b). It is observed that the velocities range from 0.03 m/s to 0.23 m/s. The velocity of flow in the network is good. All the pipes have velocity falling below 3.0 m/s [10].

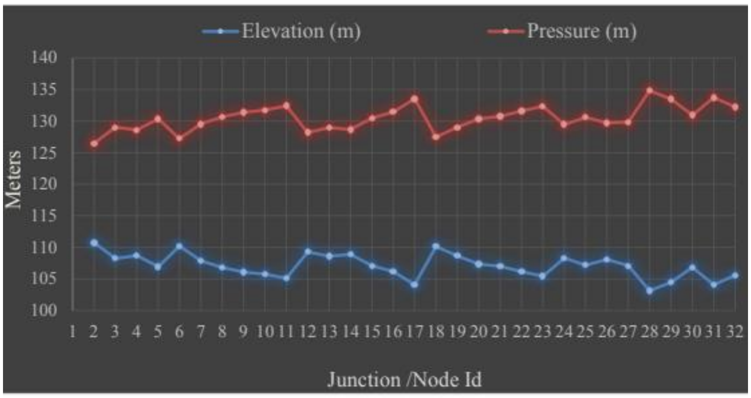


Figure 3.7: Graph representing Elevation and Pressure

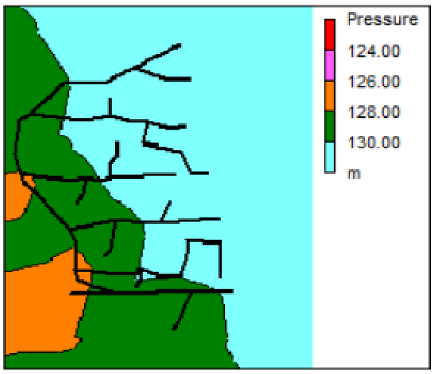


Figure 3.8: Contour Plot for Pressure

It is found from Figure 3.7 that with the reduces in the ground elevation pressure in the pipe increase and vice versa [6] and Figure 3.8 represent the Contour Plot for Pressure of the water distribution network.

4. Conclusion

In this study, Hydrological Parametric Investigation of Water Distribution Network for Sawale Village was carried out using EPANET, a computer based simulation software for a water distribution network.
Prelude to the investigation, a survey of the writing was done where the past and current system examination strategies were analyzed. The current conditions of water supply and appropriation in the Sawale village were likewise analyzed. Applicable information required for the examination was gathered. First surveyed the area and took information about the population and per capita demand of the people. And according to that we design the distribution system for the area. The consequences of all the investigation are upheld by outlines, screen-print, and pictures. The distribution layout used here is a tree system or dead end system which is according to the layout of the Sawale area.

The conclusions drawn based on the results obtained are presented further

Hydraulic programming estimates the Velocity, Unit Head loss and Friction Factor as shown in Figure 3.6 (a). Link 4 and 30 is minimum Velocity and Unit Head loss that is 0.03 m/s and 0.05 m/km and Link 1 maximum 0.23 m/s and 0.95 m/km and Friction Factor is almost the same as shown in Figure. All the pipes have velocity falling below 3.0 m/s as shown in Figure 3.6 (b).Overall about 75% of uniform pressure is obtained for portions of the common area as shown in Figure 3.8 Contour Plot for Pressure.
Graph representing Elevation and Pressure shown in Figure 3.7 it is found that with the increase in the ground elevation pressure in the pipe reduces .Node 18 increase in the ground elevation then reduces pressure and Node 17 reduces ground elevation then increases pressure and vice versa as shown in Figure. The pressures at node 17,28,29,31 are more due to their elevation.
Results signify that hydraulic simulation along with the application of GIS and EPANET software is a simple tool for the design of WDN and also helps in providing a less time consuming, sustainable and optimized WDN for Sawale village.

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