Smart Water Supply, Monitoring and Quality Control by Using Latest Techniques

Vipin J. Wankhede[1], K. P. Dandge[2]

[1]*School of Environmental and Earth Sciences, K.B.C.N.M.U. Jalgaon.*
[2]*School of Environmental and Earth Sciences, K.B.C.N.M.U. Jalgaon.*

---***---

Abstract – Water is important for human life and without water, life cannot exist on earth. Every person required 135 liter per day for drinking and demotic purpose. But due to lack of quality, inefficient water supply designs, quality of water is deteriorated specially in recent decades and affecting a number of people. In present study, it had been inevitable to style a water system system for selected area to supply safe water system design for alittle community. For this purpose, a study area was selected named as Nimkhedi Zone of Jalgaon City. The current water system system of the village was built 30 years ago with the issues of leaky pipes, beverage was causing water-borne diseases like Diarrhea, Cholera, Giardiasis, Typhoid fever, Schistosomiasis. EPANET (Environment protection agency network) is computer software was used to design a water system system of the world providing input parameters to the software. For this a profiling survey was conducted to work out the length of pipes and therefore the elevation of every junction. The other input parameters just like the diameter of pipes, pipe network map, head losses were provided. Conclusively, EPANET gave an in-depth water system system plan for specific design period. By adopting this design provided by detailed surveys of the world and EPANET will help to regulate water quality. The new design is predicated on technology by using modern techniques (Software). It provides save and continue supply of water to community. It will also reduce the value of water billing, leakage, decrease the diseases rate and improve the life standard of people's lives therein area.

Key Words: Smart Water Supply, Quality Control, Epanet, water supply, water quality sensors, water borne diseases.

1.INTRODUCTION

Now a days, 600 million Indians face high to extreme water stress and about two lakh people die per annum because of inadequate access to safe water," NITI Aayog said within the report. About two lakh people dying each year within the country thanks to inadequate access to safe water. India is suffering from 'the worst water crisis' in its history with about 60 crore people facing high to extreme water stress and about two lakh people dying every year thanks to inadequate access to safe water. Poor water quality and also un-adequate disposal of human, animal, and household wastes are contribute towards waterborne diseases. In India Just 30% of waste water from cities is treated before disposal. the remainder flows into rivers, lakes, and groundwater, it said.

According to UNICEF, the access rate to safe beverage in geographic area is 97% and 90% in geographic area. Water system rate through modern facilities like water treatment plant and distribution facilities is barely 48% in geographical area and 12% in country. To prevention from water borne diseases from polluted water. Stopped the leakages and pollution from metallic pipelines. Water Quality of treated water is monitored up to consumer level. Providing never-ending water metering, GIS, house connection meters, improvement of tariff collection.

Water distribution system is a hydraulic infrastructure consisting of elements like pipes, tanks pumps and valves etc. It is crucial to provide water to the consumers; effective water supply is of paramount importance in designing a new water distribution network or in expanding the existing one. It is also essential to research and establish a reliable network ensuring adequate head. Computation of flows and pressures in network pipes has been of great value and interest for those involved with designs, construction and maintenance of public water distribution systems. This study aimed at performing the hydraulic design of Nimkhedi Zone of Jalgaon water distribution network using Epanet Software.

Name of City, Region/state	Jalgaon, Maharashtra
Latitude / Longitude	21°0'52"N 75°33'52"E
Area in sq.km.	68.46 Sq.km.
Average Annual Rainfall (mm)	730 mm
Average altitude (mtr)	578 to 611 m above sea level
No. of Wards / Administrative Zone	69 Nos. / 12 Nos.
Population (2011)	4.60 Lakhs
Existing supply	@ 90 -100 MLD
Existing storage	MBR = 26.0 ML, ESR/GSR =(33.60 + 10.50)= 44.10 ML
Exiting Distribution piping	564.350 Km [dia 25mm to 600mm]
Water supply connections	67278 Nos

Table -1: Details of Jalgaon City Water Supply

2. POPULATION

As per provisional reports of census INDIA, population of Jalgaon in 2011 is 460,468; of which male and female are 241,228 and 219,240 respectively.

Jalgaon City	Total	Male	Female
Population (2011)	4,60,468	2,41,228	2,19,240
Literates	3,63,778	1,98,426	1,65,352
Children(0-6)	51,544	28,548	22,996
Average Literacy (%)	88.96	93.3	84.26

Table -2: Census Population 2011

3. OBJECTIVES

- To Propose Smart Water Supply System with Monitoring and Quality Control for Jalgaon City in Nimkhedi Zone.
- To measure the inflow to ESR/GSR and outflow into distribution network.
- To analyse the water quality in distribution network.
- To monitor accountability of water lost in system or due to theft etc.
- To get the pressurized water at High elevation area.
- To propose system for equitable distribution of water and meet prospective demand at desired pressure.
- To Suggest suitable phasing options for replacement old piping and HSC, to minimized NRW in system.

4. DESIGN OF DISTRIBUTION NETWORK

4.1 Data required for Design of Distribution Network

- Topography Survey (Contour) along with all the ground features of Area
- Population Data
- Water Demand
- Elevated Storage Reservoirs Levels

4.2 Methodology of Design

The distribution network has been built using the EPANet 2.0 software package. Computer aided design has been adopted for the design of distribution network. The method used by EPANet 2.0 to solve the flow continuity and head loss equations that characterize the hydraulic state of the pipe network at a given point in time can be termed a hybrid node-loop approach.

4.3 Nodal/ Segmental Population

Each distribution line has been divided into segments. A segment is a 'concentrated' or 'nodal' part of a distribution line delivering the demand flows for a fixed area. The nodal population is arrived based on the applicable area contributing to that segment to give the actual population for calculating water demand to distribution line through that segment. The above procedure has been adopted to obtain water demand for all segments. The segment populations and the ground levels (obtained through detailed survey) were compiled in a data file for hydraulic analysis. There are four types of a distribution network system.

- Dead End or Tree system
- Gridiron System
- Circular or Ring System
- Radial System.

4.4 Design Criteria

All the design norms adopted are in conformity with the standard design norms provided in the CPHEEO Manuals on Water Supply and Treatment published by MOUD, Government of India, New Delhi and relevant IS Codes.

4.5 Design Period

Water Supply Project is designed to meet the requirements of upcoming thirty-years after their completion. The time lag between design and completion of the Project should also be taken in to account which should not exceed two years to five years depending on the size of the project. A design period of 30 years with implementation period of 3 years is considered. (1)

4.6 Per Capita Supply

For cities provided with piped water supply where sewerage system exists / contemplated, the recommended maximum water supply is 135 lpcd which exclude unaccounted for water (UFW) and which should be limited to 15 %. [2]

4.7 Distribution System – System Pattern

For equal distribution of water, where the different pipelines are interconnected keeping dead ends to a minimum is recommended. The system facilitates any one point being fed at least from two different directions. For small water supplies the tree or branch system with smaller mains branching off from a single trunk main may be adequate. For design of distribution system Loop is adopted.

4.8 Zoning

Zoning in the distribution system ensures equalization of supply of water throughout the area. The neighboring zones may be interconnected to provide emergency supplies. The valves between the zones however should normally be kept closed and not partially opened. The layout should be such that the difference in pressure between different areas of the same zone or same system does not exceed 3 to 5 meters. [3]

4.9 Peak Factor

For design of distribution system hourly variation in consumption is important. The fluctuation in consumption is accounted by considering the peak rate of consumption as rate of flow in the design of distribution system. Following are the recommended peak factor. [4]

Population	Peak Factor
Population less than 50,000	3.0
Population between 50,000 and 2,00,000	2.5
Population more than 2,00,000	2.0

Table -3: Peak Factor

We have used peak factor of 3.0 in our designs, since contributory populations of each zone is below 50,000.

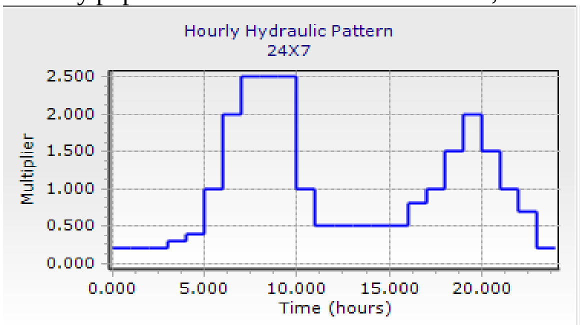

Fig -1: Hourly Hydraulic Pattern

4.10 Selection of formula for Friction Loss

Following formulae are generally followed for estimation of frictional loss in pipeline. We have used Hazen William formula for the water supply network analysis.(5)

4.11 Hazen William's formula

V = 3.83 C d0.6575* (gs)0.5525 / v0.105
Where, V = Velocity in mps,
C = pipe roughness coefficient, d = pipe diameter,
g = acceleration due to gravity, s = friction slope,
v = viscosity of liquid.

4.12 Darcy Weisbach's formula

S= H/L = f V2/2 g d

Where, H = head loss due to friction over length L in meters.
f = dimensionless friction factors.

4.13 Pipe Roughness Co-efficient- "C" values

Sr. No.	Pipe Material	C Value
1	DI	100-140
2	MS	100-140
3	HDPE	145
4	Cast Iron	130-135

Table -4: C Value

- We have Used Roughness Coefficient as 140 for Pipe material "DI - K7"
- We have Used Roughness Coefficient as 145 for Pipe material "HDPE PN-6 PE-100"

4.14 Minimum Pipe Size

A minimum pipe size of 90 mm is considered as per CPHEEO guidelines. As per terms and conditions of the contract following pipes are proposed for this project.

Diameter in mm.	Pipe Materials	Application
90 to 250	HDPE (PE100 PN6)	Distribution Network
300 to 500	DI K7	Distribution Network

Table -5: Pipe Selected for the proposed Scheme

4.15 Velocity

The maximum scoring velocity in the pipe line is 3 m/s. However, the Velocity in the pipes in the distribution network is limited to below 1.5 m/s to avoid higher head losses in the networks and to get minimum residual head of 7m at farthest and elevated locations.

4.16 Procedure to extract contour data from Geographic information system

- Boundary of Jalgaon is opened in AutoCAD Civil 3D Software.
- Set the co-ordinate system (WGS84, Zone-43N) in AutoCAD Civil 3D Software.
- By using Map export Command Generate a .Kml file.
- Open this Jalgaon Boundary file in Google Earth Pro Software.
- Marked the Rectangle of Raster Image area.
- Cad Earth Import Image Command
- Set the parameters for Google Raster Image and Topography (Contours)
- Raster Image is Downloaded now.
- By using Mesh Command Import Terrain Mesh from Google Earth.
- Now mesh is created.
- By using Cad-Earth Draw the Contour Lines from Mesh
- Set the Contour Interval Minor Contours is 1m & Major Contours 5m.
- Contour Line are Generated Now with Contour Elevation.

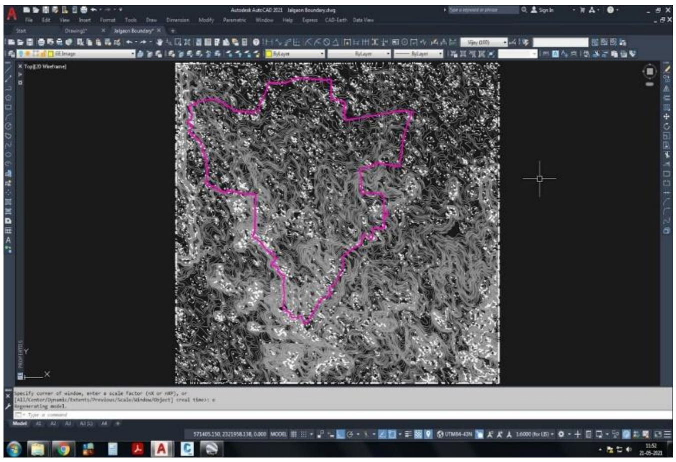

Fig -2: AutoCAD Software Window

4.17 Methodology of Hydraulic and Water Quality Analysis for Pipe Network from EPANET Software

- Draw the propose network by using backdrop image of Google Earth.
- Locate the reservoir and enter the details such as ground level, staging height.
- Allocate the elevation at each node from the contour data.

- Apply the water demand to each node or per meter length.
- Set the frictional loss formula and units.
- Locate the Control Valves, Air Valves, Pressure Reducing Valves.
- Analyzed the network whether required pressure is getting or not, if not then change the pipe dia. By trial and error.
- After getting the required pressure at each node Set the drawing at suitable scale and exports it.

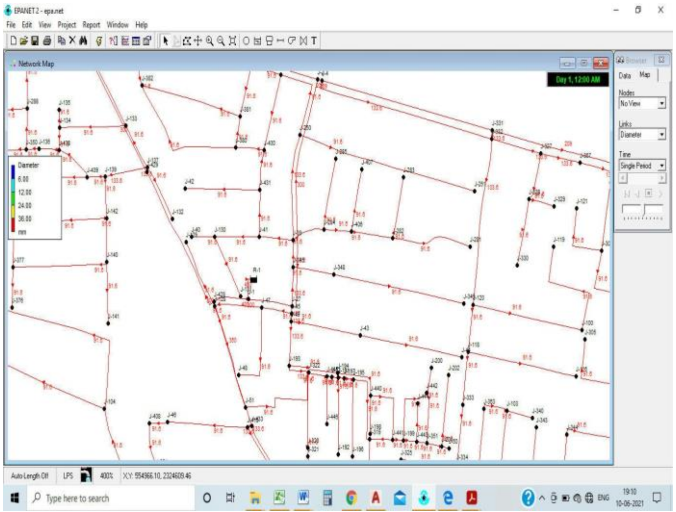

Fig -3: EPANET Software Window

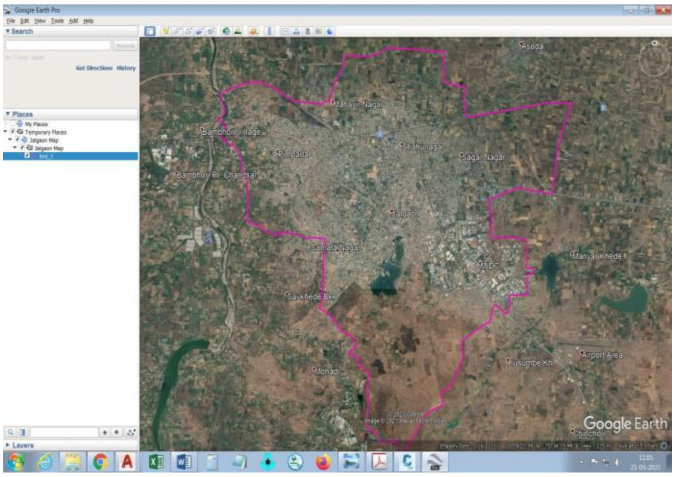

Fig -4: Google Earth Software Window

4.18 Hydraulic and Water Quality Analysis for Pipe Network from EPANET Software

The basic input data like, elevations, lengths and water demand etc., required for designing the networks are provided in to the EPANET software. The network preparation, zoning procedures followed as explained in the earlier chapter. Firstly network prepared with nodes / junction and pipelines with HDPE material. The projected population has been distributed to the zonal areas based on the converting density per meter lengths pipe line by dividing the total zonal population by the zonal pipe lengths. Based on the population density per meter length the Nodal flows are assigned as water demands to the each Node considering pipe length covered by each node. The data of 24 hour water demand is provided. The output of design details calculations are analysed with different alignments and alternatives. The design is optimized to maintain the required design guidelines such as velocity, maximum and minimum residual pressures.

5. RESULTS AND DISCUSSION

Water discharge through every tap is measured through AMR water meter. Water meter reading is automatically taken. Quality of water is continuously analysed through the Chlorine Sensors, pH Sensors. Water Quality at Consumer Tap level is maintained.

Minimum Residual Pressure remains same throughout the network by using the pressure reducing valves. Water is equally distributed in all the areas. Distribution Network is well-versed design through the hydraulic design software. Diameter wise discharge is divided and then pressure is maintained. Distribution Network is optimized through the Genetic Algorithms.

Corrected topographical data taken from the GIS Platform (Google Earth) that’s why network will perform the better results. Elevations are extracted from the Contours by using etrex in Watergems so no need to enter manually. The entire distribution network is controlled through the motorised valves, so no need of manpower to operate the network. Elevated storage reservoir water level is measured through the level sensor and it will immediately indicate in the control room.

If any leakage in the network, then it will indicate in control room that’s why huge amount of water is saved. Entrapped air is carried out from the pipelines through the Air Release Valves, then the flow of water is continuous. By using High Density Polyethylene Pipes, Water pollution due to corrosion of metallic pipelines is minimized.

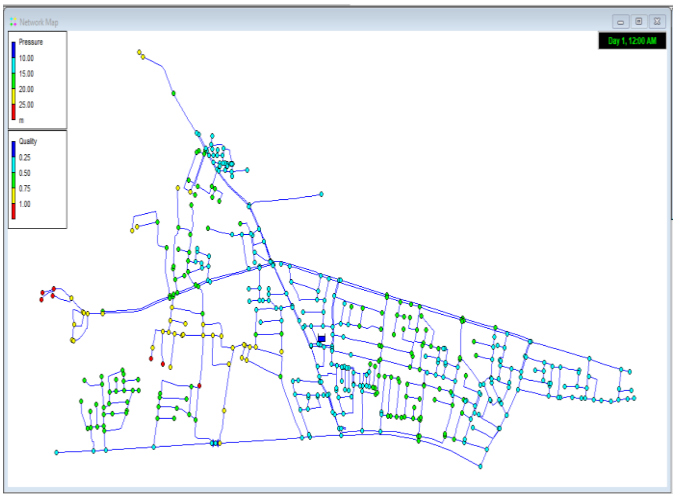

Fig -5: Distribution Network Showing Pressure and Quality

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 01 | Jan - 2022 ISSN: 2582-3930

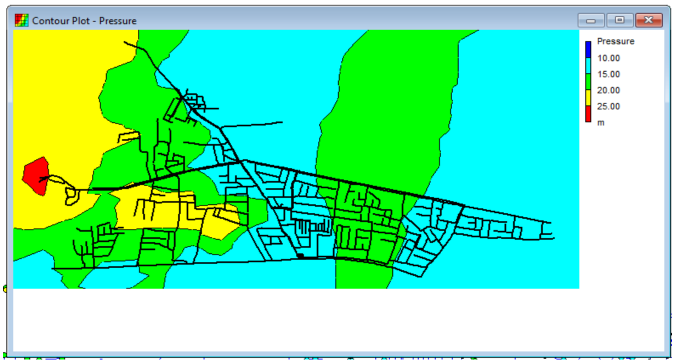

Fig -6: Map Showing Pressure in the form of Contours

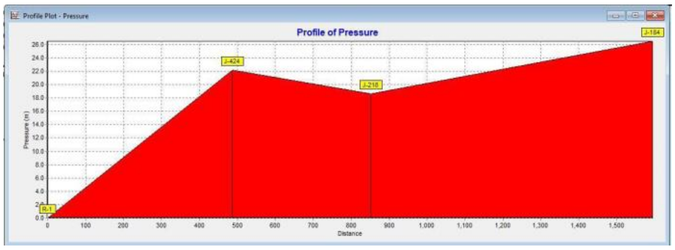

Fig -7: Profile Showing Pressure Graph of Node R-1-J424-J-218-J184

Fig -8: Profile Showing Distribution of Pressure

No. of Junctions	459
No. of Reservoirs	1
No. of Pipes	496
Flow Units	LPS
Headloss Formula	Hazan Williams

Table -6: Characteristics of Distribution Network

6. SENSORS FOR QUALITY MONITORING

Online sensors used in the drinking water network are supposed to continuously monitor and provide quantitative, high- resolution and validated measurements for assessing the water quality.

If sensors are to make measurements in the pressurized pipe, they must be very robust to be able to deliver good results regardless of pressure fluctuations and bursts. The maintenance and power requirements of online analytics must be reduced to a minimum. It provides real time data to SCADA system and to be able to react to alarms and changes in the measured data.

This sensor system is used to monitoring drinking water quality in pipes under pressure. It will monitor Up to ten parameters in one system: organic parameters (TOC, DOC, UV254/UVT), turbidity, colour, chlorine, pH/redox, conductivity, temperature and pressure. [10]

Fig -8: Image Showing Sensors are installed on pipe

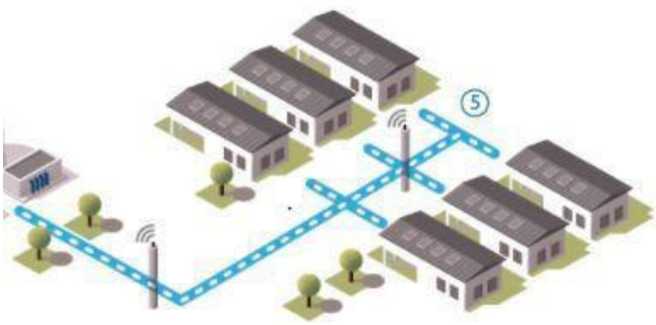

Fig -9: Image Showing Location of Sensors

7. CONCLUSION

Desired water quality can be achieved by continuously monitoring the parameters. Water losses can be minimized that's why lots of amount of water is saved. Leakages can be easily detected in the network, So water and pollution of water is minimized. Minimum residual head at consumer tap level is maintained.

Correct Topography data from GIS platform will helps to improve the network design. Water pollution is minimized due to non-metallic pipes. Due to leak detection water is saved, that's why water is saved and the water demand is easily fulfilled. Water consumption is minimized due to water meter at each consumer level. Water borne diseases are minimized.

Equal amount of water is distributed to each consumer. Water quality of treated water is maintained up to consumer level. Illegal house service connections are identified therefore reduction of non-revenue of water.

8. REFERENCES

1. Ministry of Urban Development, New Delhi, (1999), “Manual On Water Supply and Treatment”, (CPHEEO) Central Public Health and Environmental Engineering Organization, Edition III, Clause 2.2.6 – “Design Period”, Pg 6; http://moud.gov.in
2. Central Public Health and Environmental Engineering Organization, Clause 2.2.8 – “Per Capita Supply”, Pg 9
3. Central Public Health and Environmental Engineering Organization, Clause 10.2.3 – “Zoning”, Pg 360
4. Central Public Health and Environmental Engineering Organization, Clause 10.3.1 – “Peak Factor”, Pg 361
5. Central Public Health and Environmental Engineering Organization, Clause 6.2.1 – “Formula for Friction Losses”, Pg 104 – 106
6. Central Public Health and Environmental Engineering Organization, Clause 10.3.4 – “Minimum Pipe Size”, Pg 361
7. Water Supply Engineering by R. Pannirselvam.
8. Handbook on Water Supply by Central Public Health and Environmental Engineering Organisation (CPHEEO)
9. Manual on Operation and Maintenance of Water Supply Systems by Central Public Health and Environmental Engineering Organization.
10. https://www.thesourcemagazine.org/innovative-drinking-water-qualitymonitoring-with-the-pipescan/
11. Detailed Project Report on Hydraulic Design Report of Jalgaon city Published by Jalgaon Municipal Corporation.
12. Rossmann LA “EPANET 2.0 User’s manual,” Water supply and water resources division, national risk management research laboratory, Cinchinnati, 2000.
13. Demand Allocation In Water Distribution Network Modelling- A GIS Based Approach Using Vornoi Diagrams With Constraints by Nicolai Guth And Philipp Kingel.
14. EPANET water distribution system modeling software package developed by the United States Environmental Protection Agency's (EPA) Water Supply and Water Resources Division Manual.
15. Arunkumar M, Nethaji Mariappan V.E., “WATER DEMAND ANALYSIS OF MUNICIPAL WATER SUPPLY USING EPANET SOFTWARE” International Journal on Applied Bioengineering, Vol. 5, No.1, Jaunary 2011.
16. Atiquzzaman, M. and Liong, SY. 2004. Optimal Design of Water Distribution Network Using Shuffled Complex Evolution. Journal of the Institution of Engineers, Singapore, 44(1).
17. Piper, S. 2000. Estimating future water demand using population and economic growth projections: A guide for municipal, rural and Industrial (MR&I) water assessments. Economic group technical service Centre, Bureau of reclamation, Denver, Colorado.
18. Mandar G. Joshi, Nitin P. Sonaje. “A review of modeling and application of water distribution network softwares”
19. Report published by Government of Gujrat “Establishment of an Real time monitoring system (SCADA) for bulk water supply network”.
20. V.C. Sharath, S. Suhas, B.N. Sachin Jain, S.B. Vinay Kumar, C. Prasanna Kumar, “Water Quality Monitoring System Using Zigbee based Wirelss Sensor Network,” in Advances in Electronics, Computers and communications (ICAECC), 2014 International Conference on, October 2015, pp. 1-5.
21. Case Study on Designing Water Supply Distribution Network Using Epanet for Zone-I of Village Kherali.
22. Analysis and Design of Water Distribution Network Using EPANET for Chirala Municipality in Prakasam District of Andhra Pradesh.
23. Water Demand Analysis of Municipal Water Supply using EPANET Software by Arunkumar M.
24. Major Project Report on Analysis and designing of water supply and underground sewerage systems. https://pdfcoffee.com/major-project-report-final-pdf-free.html