Design and Simulation of a Water Supply System for Eramala Panchayat

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Abstract -. *A vital part of keeping us alive is water. 75% of the surface of the earth is covered by water. Only a very small portion, though, is fresh water that may be used by people, animals, and plants right away. Increasing population expansion causes a very rapid daily rise in water consumption. A well-designed network of pipes is necessary to provide a sufficient and consistent amount of water in order to satisfy the water needs of the continuously expanding population. The general characteristics of the area, such as knowledge of the primary water source, population, water consumption, need for pumps, distribution network, and water tanks, are necessary for the efficient design of the water supply system. A pipe network's analysis and design are difficult and time-consuming. There are several different pipe softwares available now for the analysis and layout of pipe networks. The road network survey is carried out using GEO Trackers, and the results are plotted using QGIS software. Using EPANET 2.0 software with additions, the current Study comprises the design and simulation of a water supply scheme. A computer software called EPANET 2.0 simulates hydraulic and water quality behaviour over a long length of time in pressurized networks.*

Key Words: **QGIS, GEOTRACKER, EPACAD, EPANET, WATERNETGEN, DESIGN**

1. INTRODUCTION

For the growth, survival and development of human health safe drinking water, sanitation and good hygiene are inevitable. Water supply systems are required to meet the requirements of public, commercial and industrial activities. The water supply system must be designed in such a way that appropriate water pressure and flow can be achieved efficiently and also to avoid contamination to potable water. A well planned distribution system is used to Convey the water from the treatment facility to the individual homes.

The objective of this study is to design and simulate a water supply system for Eramala Panchayat in Kozhikode District, Kerala. This particular locality faces water scarcity during summer season ,intrusion of salt water at the source ,lack of sufficient distribution network, frequent breakdown of ageing transmission mains and drying up of source during summer are the major problems faced at present. Hence a new water supply scheme is inevitable in this areas.

1.1 Methodology

The study starts from the preliminary data collection which includes the field data and office data. After collecting this the population forecast and survey is carried out. Later the area is plotted using QGIS. Then propose the components and finally the design using EPANET with extensions. The methodology is sequentially described in the flow chart given below:

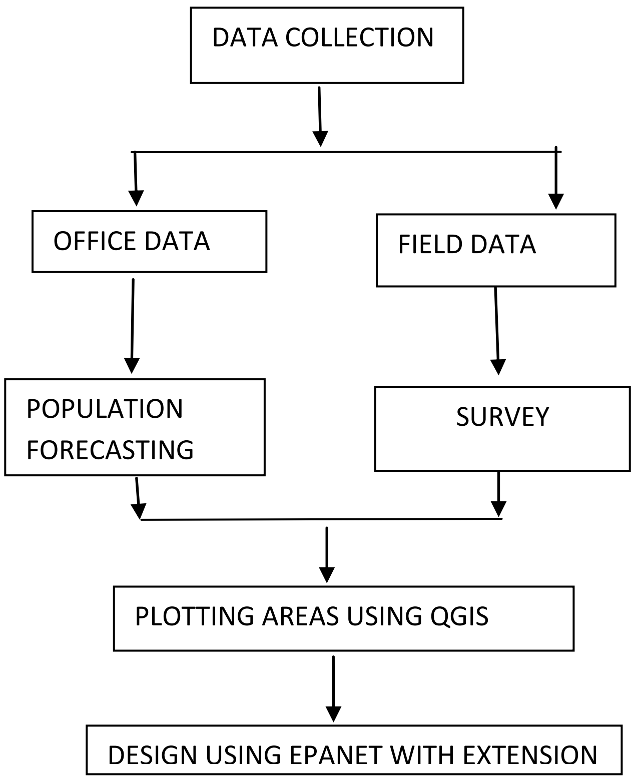

Fig 1: Flowchart of methodology

1.2 Data Collection

The study starts from the preliminary data collection which includes the field data and office data. The field data comprises of those datas collected from the study area including type of road whether NH or SH, profile of road, total length of the road, major institutions or any obstacles, population distribution etc. In this study population is forecasted based on the census datas of previous year and projected to the next 30 years, hence office data includes population, census data and present demand of the area.

1.3 Population forecasting by Arithmetical Increase Method

This method is generally applicable in large and old cities. In this method the average increase of population per decade is calculated from the past records and then added to the present population to find out the population in next decade.

Year	Population
2021	37987
2031	40866
2041	43970
2051	47074

Table 1: Projected population of Eramala

1.3.1 Water demand Calculation

After finding the population water demand is calculated, according to the CPHEEO Manual, the per capita demand adopted is 135lpcd. The losses—15% UFW and 5% other losses—are taken into account when calculating the final demand.

Year	Water Demand[MLD]
2021	5.12
2031	5.51
2041	5.93
2051	6.35

Table 2 : Water demand

The design of the components is based on the water demand obtained in each year. In this study industrial demand is excluded. Also the population above 50,000 is not observed in any of the panchayat and thus we neglect the fire demand.

1.4 Survey

Water supply network requires survey for several purposes such as establishing whether a proposed water project can supply the required volume of water for its intended users, if financially viable etc. Surveys can also provide datas like capacity of water source, to design the structures for constructing the water project.

1.5 QGIS SURVEY

The GNU Public License governs Quantum Geographic Information System (QGIS), an open source GIS which is user-friendly. DEM files that contain either raster or vector data are inserted in order to extract elevation. In this study, a raster created by CARTOSAT 2D by ISRO is employed. Through GEOTRACKERS, input data can be plotted using a mobile phone, which minimizes the difficulties of a resurvey.

Open the QGIS programme.

⇩

Open Quick Open Street Map

⇩

Choose the road from it

⇩

Access highway data with point and line layers by downloading them.

⇩

To extract vertices, use the QGIS Processing Toolbox.

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Add a layer of the digital elevation model.

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Using the information from the QGIS Toolbox Sample Raster, obtain the Elevation of Vertices.

Fig 2: Steps for computation of elevation

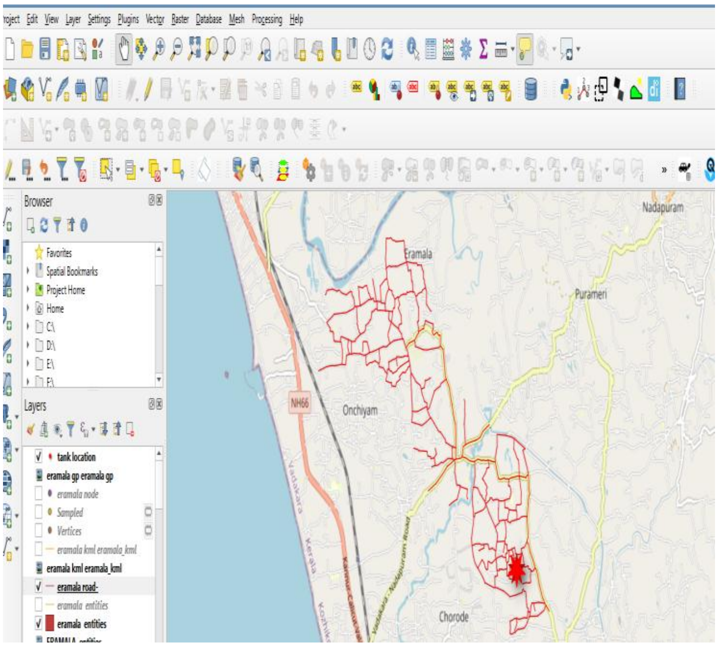

Fig 3: Study area plotted using QGIS

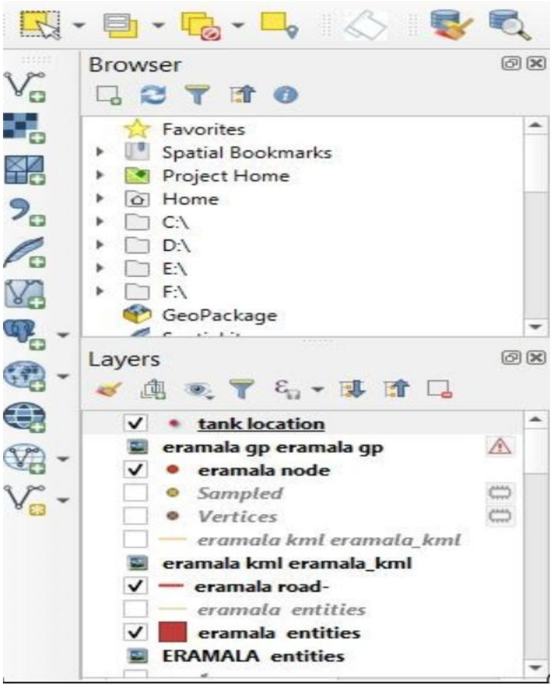

Fig 4: Browser panel in QGIS

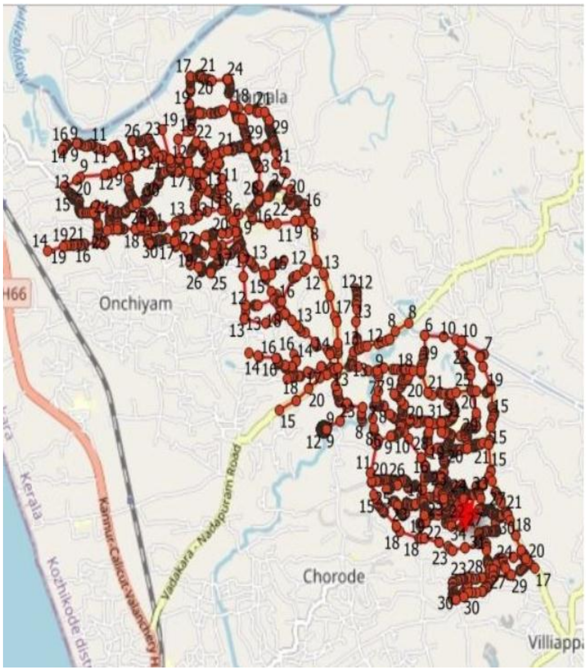

Fig 5 : Elevation in QGIS

1.6 EPACAD

EPACAD developed by ITA is a free software which easily converts an Auto Cad file into an EPANET one. EPACAD is able to automatically import the main properties of elements, largely providing the required information to build a network. It is able to read XY coordinates of Auto Cad files and elevations of nodes.

1.7 EPANET 2.0

EPANET tracks the flow of water in each pipes, pressure at each node, the height of water tank. The flow in each link and pressure head at each node is determined by EPANET. The main principle of EPANET network analysis is based on the continuity equation and conservation of energy theory. The continuity equation implies that the algebraic sum of flow rates in the pipe meeting at a node together with any external flow is zero. The conservation of energy implies that for all parts around close loops and between fixed nodes, the energy loss including minor losses minus any energy gain or heads generated must be zero.

The algorithm used in EPANET software to solve the flow continuity and the head loss equations that characterize the hydraulic state of pipe network is based on Newton Raphson iteration method for solving simultaneous equations which are derived from the flow and head loss in the network.

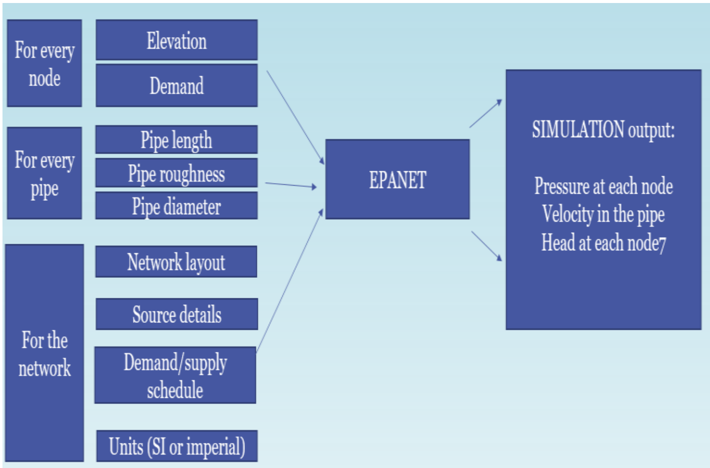

Fig 3: Basic input and output parameters in EPANET

1.8 WATERNETGEN

WATERNETGEN is an EPANET extension for automatic Water Distribution Network models generation and can also allow demand driven and pressure driven simulations. It can generate synthetic models of WDN with several hundred nodes and pipes within few minutes. The sizing capability allows the selection of commercial diameters such that the final network design satisfies certain user constraints like maximum velocity (1m/s), minimum pressure etc. The total water demand is allocated to the pipes taking into account their length and a demand coefficient.

1.9 DESIGN V/S SIMULATION

Design is the computation of parameters like diameter, flow, velocity, discharge. Whereas Simulation is the computation of flow, discharge, velocity etc. with known diameter. In this study the design of Distribution network, transmission main and pumping main. Simulation is carried out in the design of pumping main by simulating the values obtained in Excel with that of EPANET.

2. DESIGN OF DISTRIBUTION NETWORK

In order to ensure the availability of sufficient water, it becomes imperative in a modern society to plan and design sustainable water.

Entire network of Eramala Panchayat is drawn and water demand is loaded. Then the pipe catalogue is imported.For maximum velocity and minimum pressure pipe sizing is done. Finally Run the Analysis.

2.1 Design Check

Pressure check for Pressure above 7m

The pressure across each junction should be above 7m as per CPHEEO Manual. If not the design should be rechecked for pipe.

Velocity Check

The velocity through the pipes should be less than the maximum velocity ie 1m/s.

Diameter Check

The diameter of the pipe should be higher in the starting point and it get reduced when moving through the network. Also the diameter along the pipes in between should not be more than the pipes adjacent to it. In order to check this, some manual interventions are carried out.

3. CONCLUSIONS

Since all the design checks are satisfied, the design is safe to implement. The results obtained verified that the pressures at all junctions and the flows with their velocities at all pipes are feasible enough to provide adequate water to the network of the study area.

The network table for nodes is shown in table 3 with elevation, demand, head, and pressure at each nodes

Network table for links is shown in table 4 with length, diameter, roughnes, flow and velocity of each node.

Network Table - Nodes

Node ID	Elevation m	Demand LPS	Head m	Pressure m
Junc n1	7.829	0.66	41.68	33.85
Junc n8	5.195	1.01	41.08	35.88
Junc n16	3.911	0.83	40.80	36.89
Junc n41	3.192	0.76	39.28	36.09
Junc n47	3.012	0.55	39.09	36.08
Junc n50	7.428	0.44	38.02	30.59
Junc n54	8.714	0.53	37.46	28.75
Junc n95	6.853	0.94	41.42	34.57
Junc n98	6.602	0.38	41.27	34.67
Junc n107	7.249	0.48	41.03	33.78
Junc n121	6.938	0.67	40.74	33.81
Junc n128	6.724	0.61	40.31	33.58
Junc n132	6.982	0.91	40.09	33.11
Junc n134	6.192	1.04	39.81	33.62
Junc n136	6.029	0.76	39.74	33.71
Junc n140	6.472	0.61	39.52	33.05
Junc n147	5.744	0.90	39.19	33.45

Table 3: Network table of nodes

Network Table - Links

Link ID	Length m	Diameter mm	Roughness	Flow LPS	Velocity m/s
Pipe p2	151	200.00	140.000	17.95	0.57
Pipe p10	256	200.00	140.000	14.29	0.45
Pipe p17	181	200.00	140.000	13.46	0.43
Pipe p42	54.95	135.60	140.000	9.43	0.65
Pipe p45	136.6	76.00	140.000	3.24	0.71
Pipe p46	93	76.00	140.000	2.81	0.62
Pipe p88	65	76.00	140.000	1.71	0.38
Pipe p91	115	350.00	140.000	87.96	0.91
Pipe p102	138	350.00	140.000	87.48	0.91
Pipe p118	277	200.00	140.000	15.30	0.49
Pipe p119	215	350.00	140.000	86.81	0.90
Pipe p124	107	350.00	140.000	86.20	0.90
Pipe p126	149.2	350.00	140.000	83.06	0.86
Pipe p127	38.13	350.00	140.000	82.21	0.85
Pipe p128	126	350.00	140.000	79.45	0.83
Pipe p138	195	350.00	140.000	78.84	0.82
Pipe p140	171	350.00	140.000	76.98	0.80

Table 4: Network table of Links

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