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Hydraulic Parameter Analysis of WDN- A Case Study of Sayajipura Village

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Abstract

Water is an essential requirement of human being and water supply is becoming a challenging problem which is address by many researcher and attempts made towards tackling the crisis in providing safe water to the rural people in sufficient quantity, quality and at satisfactory pressure head with achieving economy constraint. EPANET software is used to design and analysis of water supply system with reference to technical sustainability. The study presents the hydraulic analysis of Pipe line network of SAYAJIPURA village near Vadodara city, Gujarat using EPANET v2.0. The village has 550 Ha area and 13,850 Population (2016). Source supplies water to village by 117 Nodes having 111 Pipes divided in two different zones. The village receives water supply from TIMBI lake located at east of city. The water from this source is taken via network of pipes to the GSR (Ground Service Reservoirs) across the village. The water from these GSR is then pumped to the Adjacent ESRs (Elevated Service Reservoirs) during the supply hours and water is supplied to the village by gravity. The results obtained verified that the pressures at all junctions, the velocities and flows in pipes are feasible enough to provide adequate water to the network of the study area. The findings will help to understand the Pipe lines system of the study area in a better way. The study also deals with the future demand of the village.

Keywords: Water Supply Network Analysis; EPANET software; EPACAD software

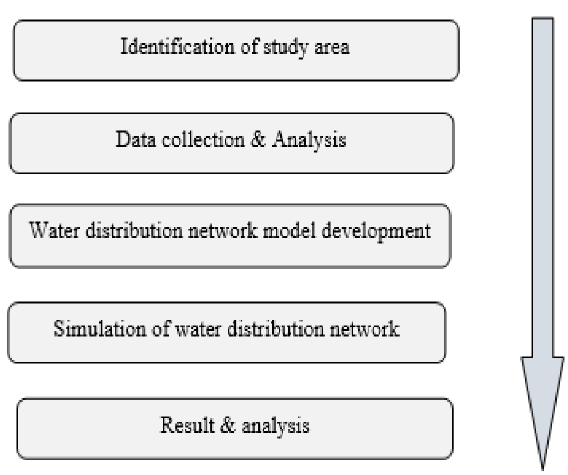
I. Introduction

Multi-village water supply system is basically recommended where the area is water scarce and where there is possibility of contamination and to find out a solution on it. There is need of studying certain methods along with some useful relevant softwares. Regional rural water supply systems that cover more than one village are becoming increasingly common in India in which villages band together and share water supply systems. This report presents the technical sustainability, an analysis and design of drinking water scheme at Sayajipura village near Vadodara city, which is a part of multi village water supply scheme.

A. *Objectives:*

- To study EPANET 2.0 and EPACAD v1.0 soft wares
- To estimate future water demand and forecast population of the study area
- To develop and analyze Water Distribution Network (WDN) of village
- To analyze Hydraulic parameters of WDN

II. Methodology



The rural regional pipeline scheme will be proposed for 11 villages near Vadodara city of Gujarat state. The nearest adequate water source for water supply scheme is Timbi lake. The location of this Lake is at Latitude 22˚18’48” and Longitude 73˚17’14”. The current population for all villages is estimated to be 28,211 souls residing in 3818.26 ha area (fig 1). For present study, water supply network of sayajipura village is analyzed which is located at latitude 22º19’40” N & longitude 73º15’19” E having population (2016) 13,850 nos. in area 556.13 ha.

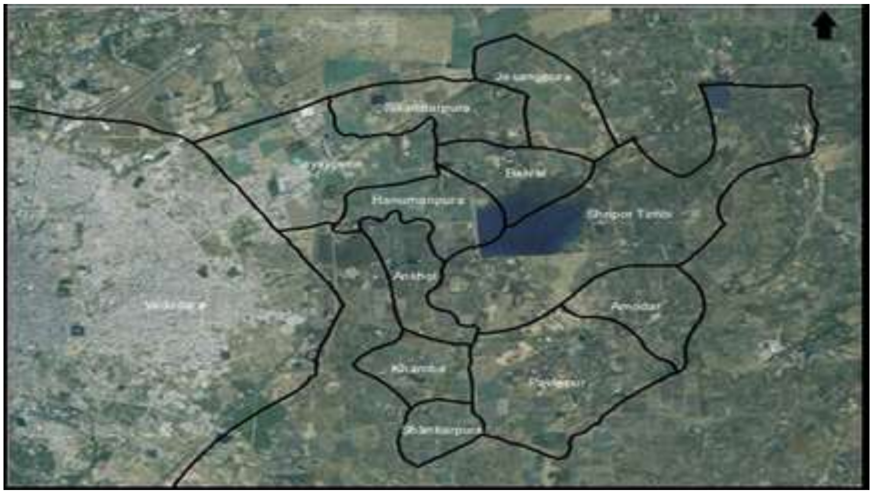


Fig. 1: Geo referencing of Study Area

B. Problems in Existing Water Supply Scheme of Sayajipura Village:

- Shortage of water supply.
- No provision of Water Treatment Plant.

C. Softwares’ Used:

- EPANET v2.0
- EPACAD v1.0
- ARC GIS v10.0

EPANET is a computer program that performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks.
EPACAD is software which allows converting AUTOCAD files into files which can be opened in EPANET.

D. ARCGIS is a Geographic information system to work with maps.

1) Data Collection:
- Census data of all villages
- Detailed Project Report (DPR) of water supply network of eastern VUDA area
- Required input parameters of Pipe and Nodes

2) Data Analysis:
a) Population Forecast:
The design population will have to be estimated with due regard to all the factors governing the future growth and development. These are the popular methods for population forecasting (Table 1, fig 2).
- Arithmetical increase method
- Incremental increase method
- Geometrical increase method

E. Water Demand Forecast:

Gross water demand is also calculated by adding 15 % unaccounted for water (UFW) in net water demand of the village .Estimation of future gross and net water demand is also carried out (Table 1, fig 3).

Table – 1
Population forecast & water demand estimation of village

Year	*2016*	*2031*	*2051*
Population (no.)	*13850*	*26759*	*39668*
Net demand (mld)	*1.83*	*3.14*	*4.45*
Gross demand (mld)	*2.11*	*3.61*	*5.12*

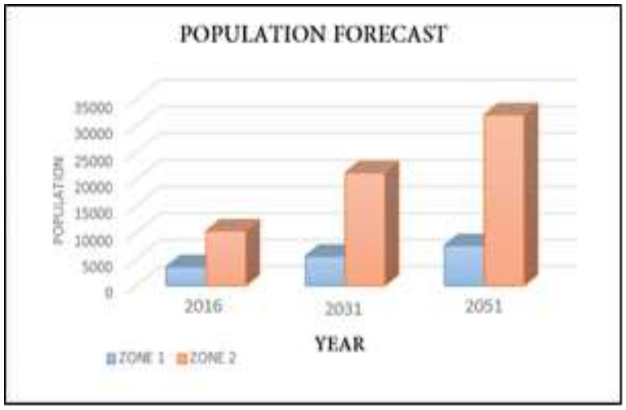


Fig. 2: Population forecasting of both zones of sayajipura village

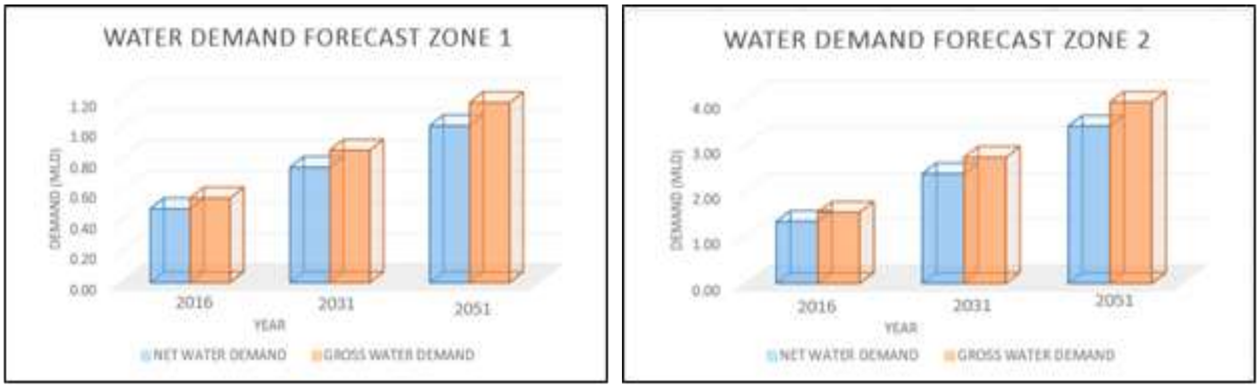


Fig. 3: Estimated water demand for both zones of sayajipura village

Storage Curve Calculations to fix Capacity of Master Sump (MS) and Elevated Storage Reservoir (ESR) for zone I is shown (Table 2). The capacity of ESR I matches with existing ESR. So, there will be no need to construct new ESR for zone I. Similarly, the capacity for ESR in zone II can be fixed. The pumping machinery is also designed for both zones (Table 3). It is proposed to install 2 Nos. (1 working + 1 Standby) new pumps of submersible centrifugal type having 15 KW, 19 HP Of 29.94 LPS discharged against of 25 m head to supply water in ESR I from MS. It is proposed to install new pumps of submersible centrifugal type of 29 KW, 38HP 3 Nos. (2 working + 1 Standby) Of 47.74 LPS discharged against of 32 m head to supply water to ESR II from MS.

Table - 2
Storage curve calculation to fix capacity of MS & ESR I

Period in hours		20 Hrs incoming but 8 Hrs continuous supply					
		Supply Rate	Cummulative Supply	Demand Rate	Cummulative demand	hourly surplus or deficit	Cummulative surplus or deficit
0	1		0.00		0.00	0.00	0.00
1	2		0.00		0.00	0.00	0.00
2	3		0.00		0.00	0.00	0.00
3	4	0.256	0.26		0.00	0.26	0.26
4	5	0.256	0.51		0.00	0.26	0.51
5	6	0.256	0.77		0.00	0.26	0.77
6	7	0.256	1.02	0.640	0.64	-0.38	0.38
7	8	0.256	1.28	0.640	1.28	-0.38	0.00
8	9	0.256	1.54	0.640	1.92	-0.38	-0.38
9	10	0.256	1.79	0.640	2.56	-0.38	-0.77
10	11	0.256	2.05		2.56	0.26	-0.51
11	12	0.256	2.30		2.56	0.26	-0.26
12	13	0.256	2.56		2.56	0.26	0.00
13	14	0.256	2.82		2.56	0.26	0.26
14	15	0.256	3.07		2.56	0.26	0.51
15	16	0.256	3.33		2.56	0.26	0.77
16	17	0.256	3.58	0.640	3.20	-0.38	0.38
17	18	0.256	3.84	0.640	3.84	-0.38	0.00
18	19	0.256	4.10	0.640	4.48	-0.38	-0.38
19	20	0.256	4.35	0.640	5.12	-0.38	-0.77
20	21	0.256	4.61		5.12	0.26	-0.51
21	22	0.256	4.86		5.12	0.26	-0.26
22	23	0.256	5.12		5.12	0.26	0.00
23	0		5.12		5.12	0.00	0.00
		5.12		5.12			
					Storage Required =		1.536

Period in hours		8 Hrs incoming but 6 Hrs continuous supply					
		Supply Rate	Cummulative Supply	Demand Rate	Cummulative demand	hourly surplus or deficit	Cummulative surplus or deficit
0	1		0.00		0.00	0.00	0.00
1	2		0.00		0.00	0.00	0.00
2	3		0.00		0.00	0.00	0.00
3	4		0.00		0.00	0.00	0.00
4	5		0.00		0.00	0.00	0.00
5	6		0.00		0.00	0.00	0.00
6	7	0.146	0.15		0.00	0.15	0.15
7	8	0.146	0.29	0.195	0.20	-0.05	0.10
8	9	0.146	0.44	0.195	0.39	-0.05	0.05
9	10	0.146	0.59	0.195	0.59	-0.05	0.00
10	11		0.59		0.59	0.00	0.00
11	12		0.59		0.59	0.00	0.00
12	13		0.59		0.59	0.00	0.00
13	14		0.59		0.59	0.00	0.00
14	15		0.59		0.59	0.00	0.00
15	16		0.59		0.59	0.00	0.00
16	17	0.146	0.73		0.59	0.15	0.15
17	18	0.146	0.88	0.195	0.78	-0.05	0.10
18	19	0.146	1.03	0.195	0.98	-0.05	0.05
19	20	0.146	1.17	0.195	1.17	-0.05	0.00
20	21		1.17		1.17	0.00	0.00
21	22		1.17		1.17	0.00	0.00
22	23		1.17		1.17	0.00	0.00
23	0		1.17		1.17	0.00	0.00
		1.17		1.17			
				Storage Required =			0.146

Table – 3
Design of pumping machinery for zone I

1	Population of 2031	=	5555	souls
2	Water Demand of	=	862413.75	liters
		=	0.86	mld
3	Hrs of Pumping	=	8	Hr.
4	Rate of pumping	=	0.11	mlh
		=	107801.72	lph
5	provide 1 pump	=	107801.72	Lph/pump
		=	**29.94**	**Lps/Pump.**
6	Lowest suction R.L	=	37.8	mt
7	Max F.S.L. of E.S.R	=	56.45	mt
8	Static Lift	=	18.65	mt
9	Residential Head	=	3.50	mt
10	Head Loss			
	From 1-2	=	2.62	
	Total	=	2.62	m
	Total Lift	=	24.77	
	say	=	**25.00**	**m**
11	H.P Required=		Q x H x 1.1 / 75 x E	
		=	18.30	HP
		=	**19.00**	**HP**
12	K.W Required=	=	14.17	KW
		=	**15.00**	**KV**

F. Water Distribution Network Model Development:

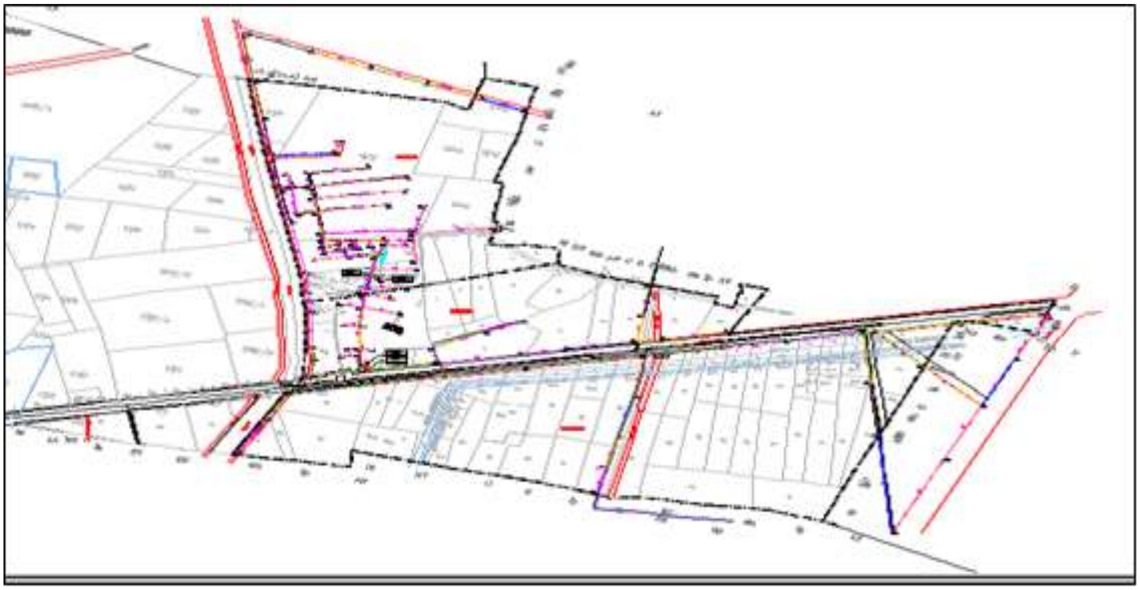


Fig. 4: AutoCAD drawing file of sayajipura

The water supply network of village is converted into EPANET network (fig 5) from AUTOCAD drawing file (fig 4) using software EPACAD. The network is completed by connecting GSR of the village with the Master Sump (MS), which provides water to GSR of all other villages. GSRs of all villages are also connected (Fig 6). After inputting following parameters for all nodes and pipes, the model of WDN is getting RUN SUCCESSFUL (Fig. 7). Graphical representation of all the output parameters of Nodes and Pipes are also shown in fig respectively. For all graphical representations, limited value of those parameters are indicated as per CPHEEO manual, 1999.

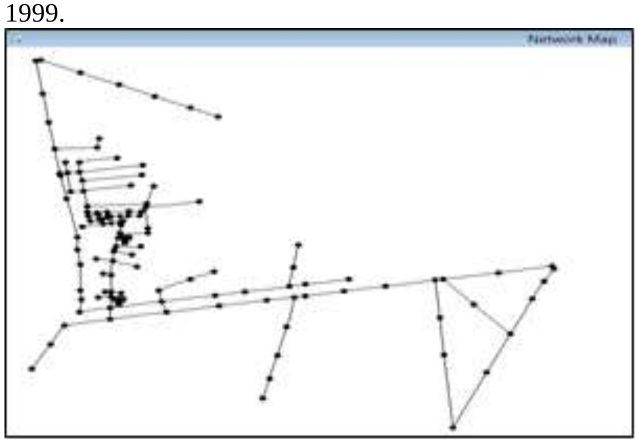


Fig. 5: .Net file converted from .dwg file of water supply network WDN using EPACAD

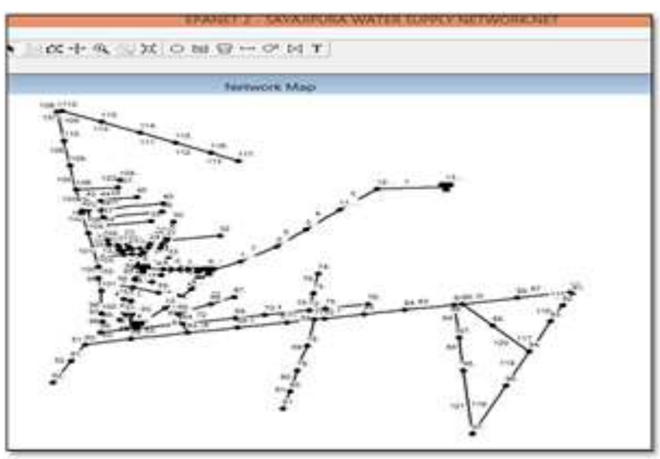


Fig. 6: Water distribution network in EPANET

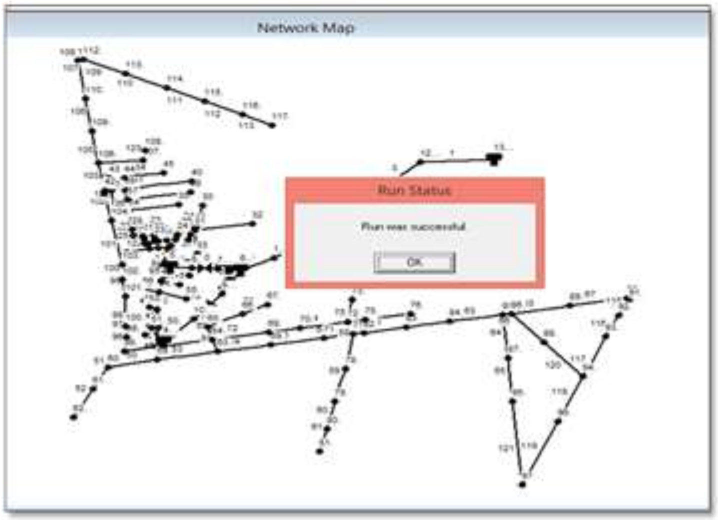


Fig. 7: Model run successful

The expected material selected for the pipe distribution analysis is ductile iron (DI) for rising mains and polyethylene (PE) with the roughness coefficient for Hazen-Williams 130 and 140 respectively. WDN contains 117 nodes connected by 111 links. The developed model of WDN of the village is superimposed on google earth image by using software ARCGIS (fig 8).

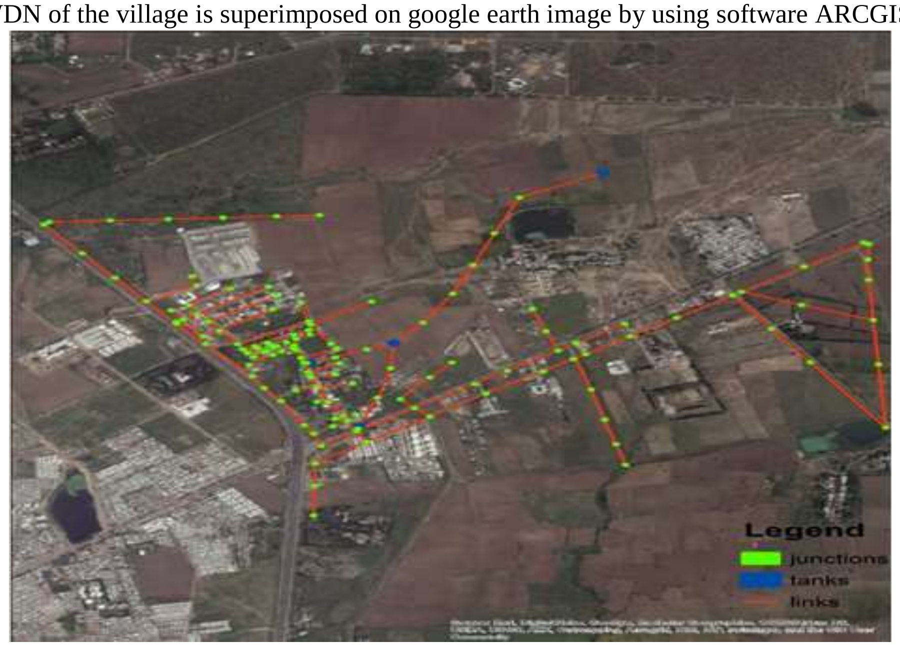


Fig. 8: Georeferencing of Water Distribution Network of Sayajipura Village Using ARCGIS

III. Result and Analysis

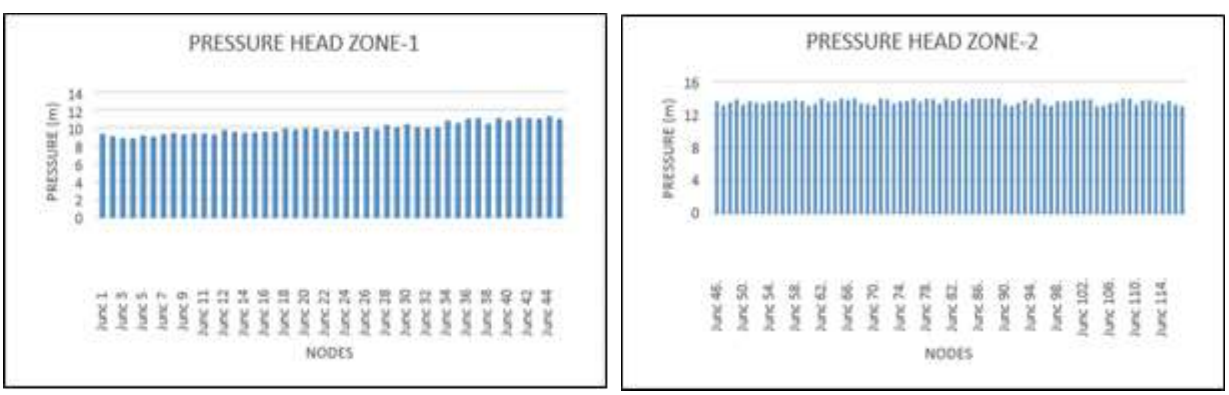


Fig. 9: Pressure head at each node of both zones of sayajipura village

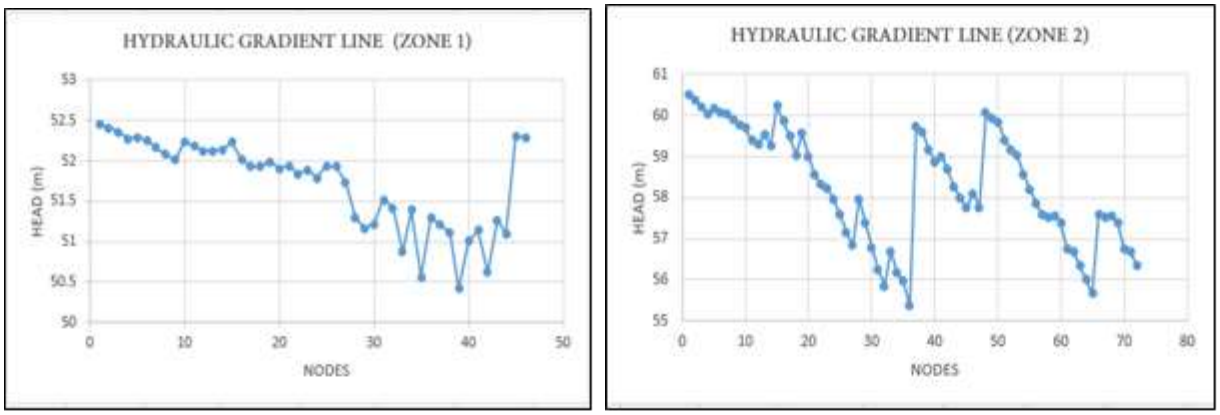


Fig. 10: HGL for both zones of sayajipura village

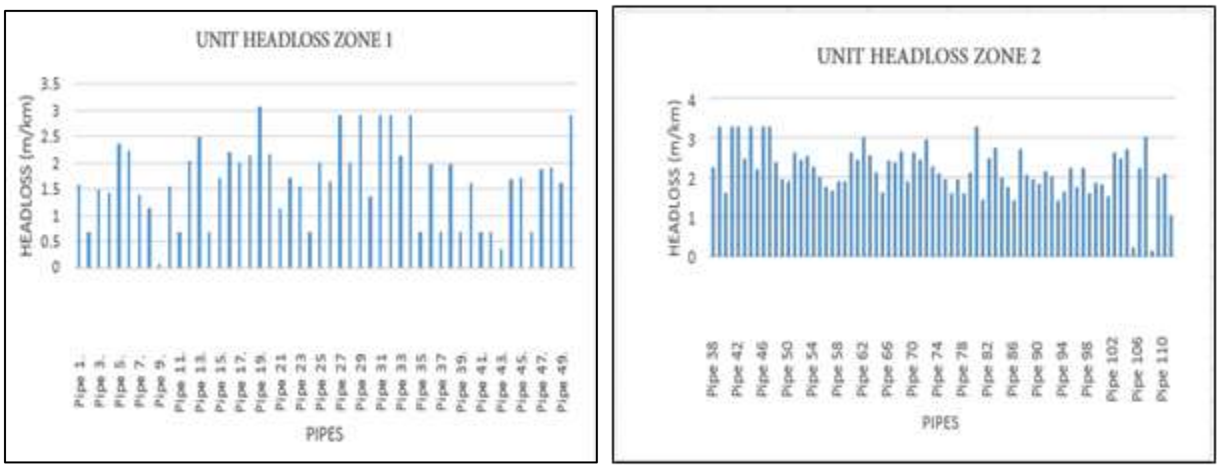


Fig. 11: Unit head loss at each pipe of both zones of sayajipura village

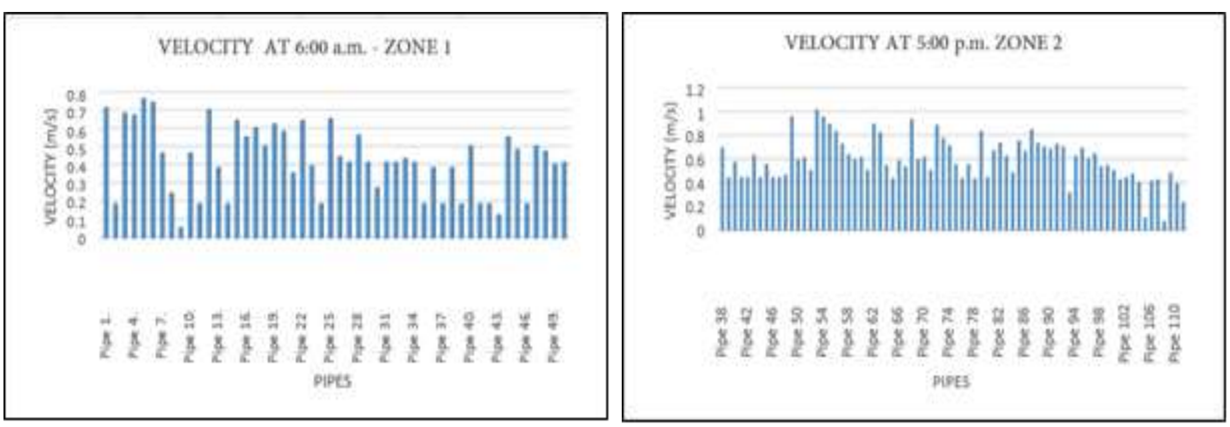


Fig. 12: Velocity representation of each pipe of both zones of village at different time

Table – 4
Analysis of output parameters

Parameter	*Maximum value*	*Minimum value*
Pressure	*14.00 m at node 95*	*8.84 m at node 4*
Velocity	*1.05 m/s at pipe 53*	*0.24 m/s at pipe 111*
Unit head loss	*3.29 m/km at pipe 46*	*0.23 m/km at pipe 105*

– For area, where two storied buildings are common, the minimum pressure of 7 m is needed for supplying water to ground level storage tanks, as per the CPHEEO manual (1999).
– The velocity should below 1 m/s for rural water supply and minimum velocity of 0.6m/s should be present to avoid silting in the lines as per CPHEEO manual, 1999.
– According to AWWA (American Water Works Association) the maximum value of head loss should not be more than 10m/km.

IV. CONCLUSION

The pressures at all the nodes are ranging from 8.84 m to 14 m, which is above the minimum pressure of 7 m (Fig 9).
The velocities in most of the links/pipes are in the range below 1 m/s (Fig 12). Further, velocities more than 1 m/s are observed in few links which is due to sudden change in diameter of pipes.
The head losses in all links are in range of 0 to 10 m/km (Fig 11).
At the end of the analysis, it has been found that the resulting pressures at all the junctions and velocities in all the links are adequate enough for water supply to the GSRs (Table 4).

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