International Journal of Engineering Research and General Science Volume 3, Issue 4, July-August, 2015
ISSN 2091-2730

A Compressive Study of Water Loss in Urban Water Distribution System

Manoj Arun Raskar , Prof. Sagar Gawande

Department of Civil Engineering, Anantrao Pawar College of Engineering and Research, Pune, manojraskar14@gmail.com

Abstract- The urban water distributing systems are suffering huge quantity of water loss while distributing water through pipe network. The water production and consumption data required to evaluate water loss but unfortunately this data were not available with the local bodies in developing cities. This paper review a method developed for measuring water loss under such condition where meters were not available to measure volume of water at every point in a distribution system. The water balance table developed by IWA/AWWA is used to identify the point of entry and exit of water throughout the distribution system for analysis water loss.
The water supply through municipal corporations of Ahmednagar was selected to execute proposed methodology. Random field survey was carried out to collect required data and it was consist of actual field measurement and physical inspection. Personal interview for daily consumption was used to evaluate water quantity. The collected data will make possible to evaluate water loss in the city and allowing for planning and actions that must be programmed to prevent additional water and revenue losses.

Keywords- Water losses, Efficiency of water distribution network, Field survey.

INTRODUCTION

Water loss is major problem of water distribution system and it is even more challenging in upcoming days as water demand increasing due to rapid urbanization, development, climate change and change in lifestyle and the water resources are limited. The efficient water management is very important as we know that water cannot be created. The efficiency of water distribution system in urban areas was affected due to high water loss. Water loss varies from 3% to 70% from developed countries to developing countries.
As per World Bank study annually more than 32 billion m^3 treated water lost in distribution network, 16 billion m^3 delivered but not invoice because of theft. The loss of treated water in the distribution network results in direct loss of revenue for water supply agency.
Potable water supply in urban areas were operated and managed by mainly Municipal Corporation. Most of the municipal water distribution network build ago and suffering huge water loss in it. As a result they were failing to fulfill current need of water demand of the city.
The Ahmednagar water distribution systems were built in 70's and currently in need to analysis and evaluation of water loss. As raw water resource is far away from city 35 km, the available water management and distribution is more important. Drinking water demand of Ahmednagar city is not fulfill, also the available infrastructure and resources are limited. In all water distribution network water losses occur in various elements but their quantity varies and broadly depends on the physical characteristics of pipe network, operation and maintenance of system, level of technology used by experts to evaluate and control losses.
Evaluating and quantifying water loss is very important need if considering present water coverage in Ahmednagar city. Quantity of water losses are subjected to variation and complex work to evaluate and quantify. In order to evaluate water loss the entire city were divided into different zones and actual daily consumption, onsite discharge measurement at consumer end were recorded and used.
The overall water demand consists of residential, commercial, industrial, public water use and unaccounted water loss and leakage. All components generate revenue to water utility except water loss and leakage which are major source of revenue loss. The evaluation of water loss and reducing water loss and leakage is an attractive solution for minimizing revenue loss.

LITERATURE REVIEW

According to World Bank study about 48 billion cubic meters of water is lost annually from water distribution system, costing water utilities approximately US 14 billion per year around the world (kingdom el at 2006). The quantity of water loss or non revenue water is a measure of the operational efficiency of a water distribution system (wallance 1987), and high level of NRW are indicative of poor governance (McIntosh 2003) and poor physical condition of the water distribution system (Male et ai. 1985).
Magnitude of water loss is greatly varies from city to city or from one area to another. Water loss is a problem experienced in all water distribution systems. The first and foremost cause of water loss is leakage. Water put to inappropriate or excessive uses may also be considered as loss. Water that is unaccounted for because of measurement errors, including inaccurate meters, forgotten users, and unmeasured uses, are also some of the causes for water losses. Unaccounted for water is one of the commonly used methods for evaluating the water loss that is usually defined differently by different writers.
There is no universally applied or accepted definition of unaccounted for water as Unaccounted for water is the difference between the water supplied to a distribution system and water that leaves the system through its intended use (Richard G. et al. 2000)

The amount of water lost in a distribution system can be quantified by conducting a water balance. There are two main water balance methodologies used for quantifying the volume of water losses:

[A] The IWA/AWWA standardizes water balance methodology (Alegre et al. 2006; AWWA 2009).

[B] The UK water balance methodology (Farley and Trow 2003; Lambert 1994). These water balance methodologies evolved from earlier works in the United States by Male et al. 1985 and the water Research Foundation (Wallance 1987).

The water balance is an effective tool for systematic accounting of water supply and consumption. The United Kingdom water balance differs from the IWA/AWWA methodology mainly in terminology used, for example, the term "apparent losses" is not used in the UK methodology, which focuses mainly on leakage computation. In addition, the UK methodology consider meter under registration as part of revenue water, thereby under declaring NRW (Mutikanga et al. 2011).

Although water loss occurs in all distribution system, in many water networks losses are even larger than 30 to 40 %, attributable to aging, deterioration of system components such as pipes and valves and incorrect management.(Nicola Fontana 2012).

Evaluations of water losses based on two major components of uncontrolled water in water distribution network are physical losses in mains and service connections and the volume of water consumed. (By Almandoz al 2005)

The literature review was focusing on the water losses in a distribution system, cause of water losses, the consequence of water loss, methods of evaluating water loss, etc.

METHODOLOGY

As the Ahmednagar water distribution system were in working since 70's the existing pipe network data were not available with the authority. For execution, it is necessary to generate primary data through field survey. Checklist was prepared to collect data in systematic format. The checklist consists of two kinds of information namely, Preliminary and Observations & Measurements. The treated water flow at consumer end was measured using simple 5 liter capacity of drum. The time required to fill the drum was measured and the rate of flow was calculated in liters/min. considering total time of water supply, volume of water received at consumer end was calculated. In this paper a key resource used to evaluate water loss is water balance method which was developed by Standard Component of Water Balance for Transmission or Distribution System (IWA 2001).

Table 1: Water Balance Table

<table>
<tr><td rowspan="8">System Input Volume</td><td rowspan="3">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="6">Non Revenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Metering Inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and or Distribution Mains</td></tr>
<tr><td>Leakage and Overflow at Utility Storage Tank</td></tr>
<tr><td>Leakage on Service Connections up to Point of Customer Metering</td></tr>
</table>

SURVEY

Random field survey was used to collect data. Six samples were collected in each zone to provide a practical means of enabling the data collection and processing components of research to be carried out. The six samples were collected in six zones in month of February 2015. The samples were labeled namely, A, B, C, D, E, F. The location of sample was decided where the entire family used treated tap water supplied from the Ahmednagar Municipal Corporation and there is no alternate source of water. The location was selected random with reference to the source of supply from reservoirs.

DATA COLLECTION

The collected data were tabulated in systematic format with all necessary calculation.

Table 1: Samples collected in February 2015 month

Sr. No.	Zone No.	Samples	Discharge (Liter/Min)	Duration of Supply (Min)	Quantity of water (Liters)	Frequency in (Days)	Water at consumer end (Liters)	No. of users	Water use (Lcpd)
1	Zone I	A	22	54	1187	2	593	6	99
2		B	17	60	992	2	496	5	99
3		C	26	60	1536	2	768	8	96
4		D	18	43	762	2	381	4	95
5		E	30	47	1400	2	700	7	100
6		F	17	48	808	2	404	4	101
7	Zone II	A	16	50	778	2	389	6	65
8		B	17	40	698	2	349	5	70
9		C	16	35	560	2	280	4	70
10		D	23	50	1155	2	578	8	72
11		E	21	48	991	2	496	7	71
12		F	17	45	743	2	372	5	74
13	Zone III	A	10	90	940	4	235	5	47
14		B	18	40	732	2	366	6	61
15		C	19	75	1395	4	349	4	87
16		D	20	40	784	2	392	4	98
17		E	28	55	1526	2	763	7	109
18		F	25	35	860	3	287	5	57
19	Zone IV	A	21	35	742	3	247	6	41
20		B	12	80	932	4	233	5	47
21		C	10	85	858	4	214	4	54
22		D	17	34	564	2	282	7	40
23		E	24	38	912	3	304	5	61
24		F	16	32	509	2	254	8	32
25	Zone V	A	15	30	438	2	219	3	73
26		B	21	43	922	3	307	6	51
27		C	11	90	1018	4	254	4	64
28		D	17	47	795	2	398	7	57
29		E	18	36	632	2	316	5	63
30		F	10	82	827	4	207	4	52
31	Zone VI	A	20	50	1018	2	509	6	85
32		B	22	46	991	2	496	5	99
33		C	30	34	1006	2	503	6	84
34		D	16	60	952	2	476	5	95
35		E	33	35	1166	2	583	7	83
36		F	39	40	1571	2	786	8	98

RESULT AND DISCUSSION

The collected data samples were analyse using the parameters like rate of discharge, duration of supply per capita consumption and demand & supply difference.

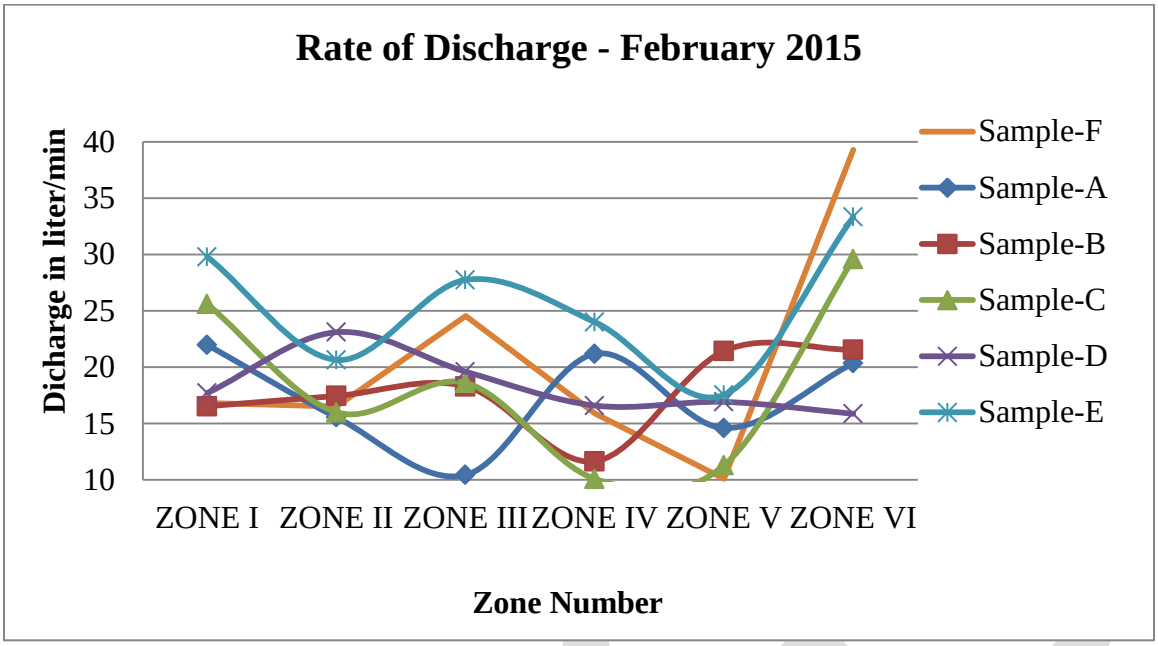

Figure 1 showing graphical representation of rate of discharge.

In the month of February at sample station F in Zone-VI found highest rate more than 35 liters/ min. The lowest rate of discharge at consumer end was observed at sample station C in Zone IV, sample station C in Zone V and Sample station A in Zone III. The highest variation of rate of discharge was observed in Zone VI. The rate of discharge was found considerable constant in the range of 15 to 25 liters/ minute in Zone II. From the above discussion we can conclude that the rate of discharge in the city varies from place to place. Low rate shows high pressure head loss in the distribution pipe network.

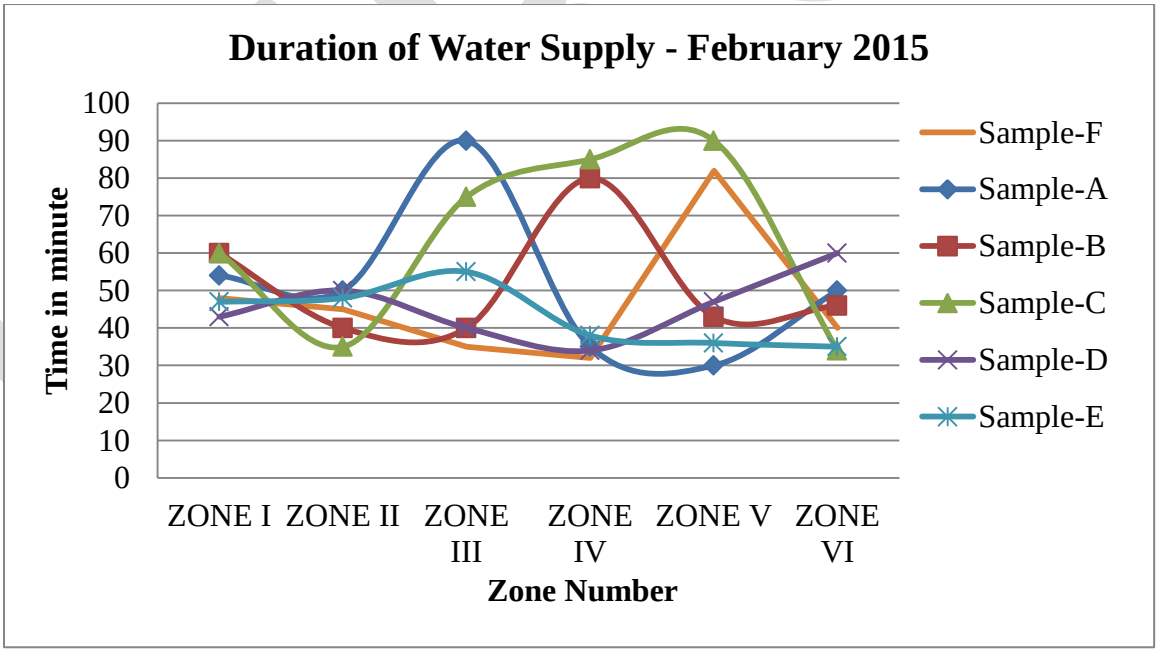

Figure 2 showing graphical representation of duration of water supply

The highest duration of water supply in the city was observed 85 & 90 minutes in Zone III at sample station A. The lowest duration of water supply in the city were observed in Zone V at sample station A 30 minutes. The moderate rate of duration of supply was observed in Zone I and Zone VI. From the above discussion we can conclude that, the duration of water supply in the entire city found very low as compared with the developing cities in India. This may not sufficient to fulfill current demand of the city.

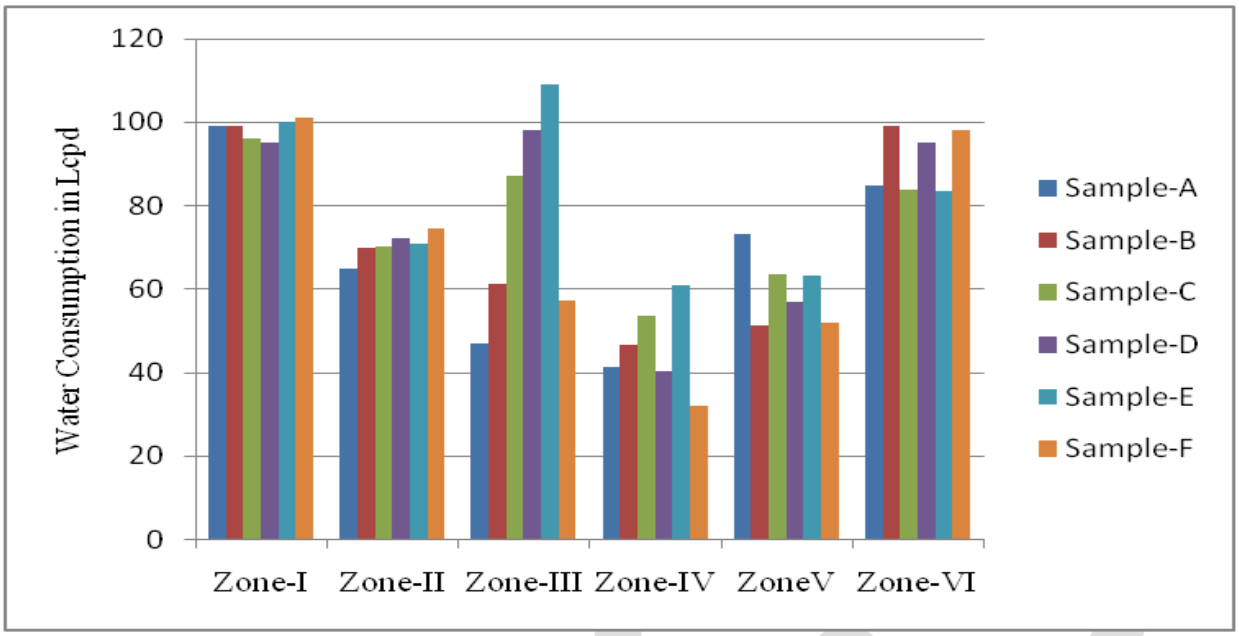

Figure 3 showing graphical representation of actual maximum daily consumption of water in each

From the analysis of random field survey great variation was observed among the consumption data of the samples located in newly developed area in Zone I and old city area in all of the rest Zones. The highest rate of consumption was found in Zone I (109 lcpd) while the lower consumption was found in Zone IV (32 lcpd).

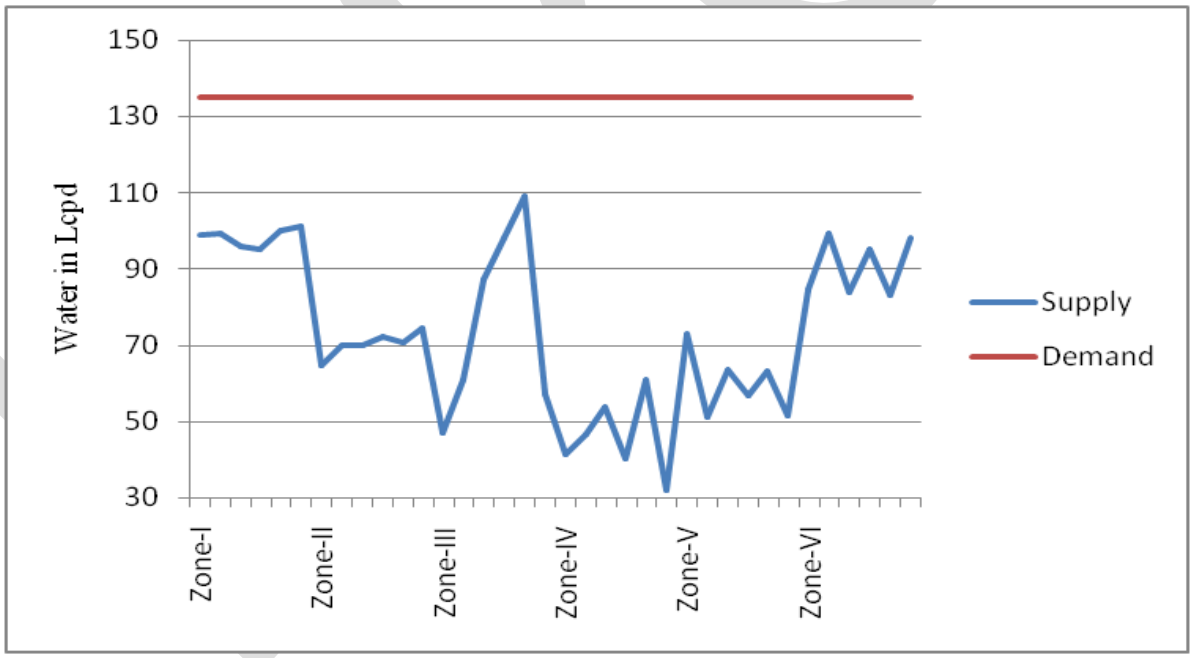

Figure 4 showing graphical representation of demand and supply difference

The highest difference in demand & supply were observed in Zone IV and Zone V where supply rate were in the range of 30 lcpd to 70 lcpd. There were considerable difference in demand and supply was observed among all six Zones. From the above analysis we can conclude that the available treated water was not reached to consumer in full volume due to high water loss in distribution pipe network.

WATER LOSS

The water loss in each zone was calculated using the actual average daily consumption of water and population data. The volumes of water supplied through reservoirs were compared with the actual consumption. Water loss is expressed in terms of percentage of net volume of water production and calculated using the following equation

$$\text{Total Water loss} = \frac{(\text{Total water production} - \text{total water consumption}) \times 100}{\text{Total water production}}$$

Table 3 Water losses in each zone

Zone	Population	Daily Consumption	Outflow	Inflow	Water Loss	%Water Loss
1	27491	98	2.69	4.5	1.81	40.13
2	28583	70	2.00	4.5	2.50	55.54
3	25322	77	1.95	4.5	2.55	56.67
4	29394	46	1.35	4.5	3.15	69.95
5	9494	60	0.57	1.0	0.43	43.04
6	8594	91	0.78	1.0	0.22	21.79
Total			9.35	20.0	10.65	AVG = **53.26%**

Where-

Zone = Zones of city
Population = Population covered in each zones in Nos.
Daily consumption = Daily water consumption in Lcpd.
Outflow = outflow in MLD
Inflow = Inflow in MLD
Water Loss = Water loss in MLD

The percentage of water loss according to this methodology given below- (10.65/20.0) X 100 = 53.26 %.

The average water loss found in six Zones was 53.26 % from the above calculation. The highest water loss was observed in Zone IV (69.95%) where lowest water loss was observed in Zone VI (21.79%). The red colors used to show highest water loss, yellow showing moderate water loss and green color shows low water loss compared to other Zones.

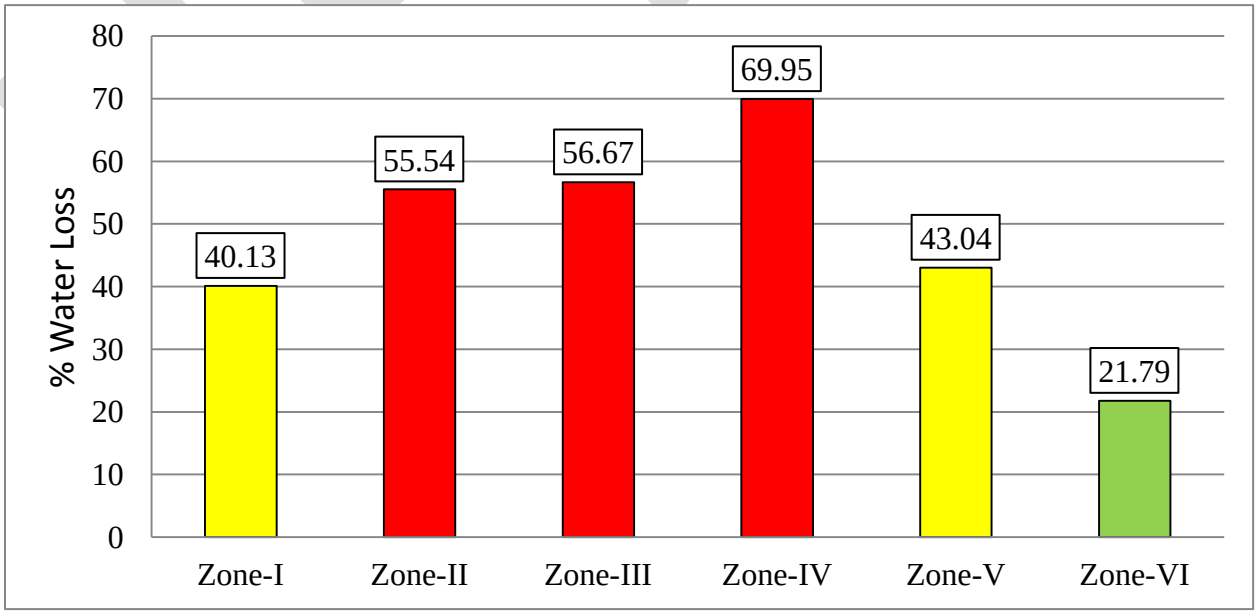

Figure 5 showing graphical representation percentage water losses in six zones

CONCLUSION

From the above observation and discussion it was concluded that the rate of discharge in the city varies from place to place. Low rate of discharge shows high pressure head loss is in the distribution pipe network. It may be due to longer distance of travelling of water in pipe interconnecting network. This data will be useful to do further researcher work to analysis water distribution system of Ahmednagar city.

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