Assessment of Quality of Distributed Water in Miraj City - A Case Study

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Abstract- **The quality of water changes during its travel in Water Distribution System (WDS). There were many complaints about the quality (odour, taste, and color) of supplied water in Miraj city. The city has six different water distribution zones with intermittent water supply. The present study was carried out to examine how the water quality changes in Shivajinagar area of Miraj city. The locations of monitoring include at Water Treatment Plant (WTP), Elevated Service Reservoirs (ESR), intermediate points within the network and remote points during the period October to December 2017. The parameters analyzed included residual chlorine, turbidity, total coliforms by Most Probable Number (MPN), pH, chlorides concentration, Total Hardness (TH), Total Dissolved Solids (TDS), and Electric Conductivity (EC). It was observed that residual chlorine, turbidity, and MPN significantly changed. The study concluded that there was quality deterioration of water at WTP and other locations in the study area. The observations from the current study will help to improve the operation of water distribution system of the city.**

Index Terms— Microbial Quality, Residual Chlorine, Water distribution system, Water Quality.

I. INTRODUCTION

A water supply system consists of infrastructure that collects, treats, stores, and distributes water between water sources and consumers. The purpose of the distribution system is to deliver water to the consumer with appropriate quality, quantity, and pressure. In 2010, about 87% of the global population had access to the piped water supply through house connections. The World Health Organization (WHO) and United Nations International Children's Emergency Fund (UNICEF) have estimated that 1.1 billion people worldwide, especially in rural areas and low-income communities, do not have access to safe drinking water (WHO and UNICEF, 2000). In developing country like India, Intermittent supply is adopted. In treat and supply system, between leaving a treatment plant and arriving at the consumer's tap, drinking water enters the distribution network where it resides for periods that typically range from hours to days. During this time, the drinking water may become contaminated via a range of processes. The quality of water deteriorates in networks due to regrowth or entrainment of untreated water through damaged pipes, presenting potentially serious health risks to consumers (WHO 2000). Water quality failure in the distribution system could occur as a result of water treatment failure, failed or compromised pipes and cross-connections, regrowth of microbes in pipes and distribution storage tanks, leaching of chemicals or corrosion products from system components (pipes, tanks, liners) and intentional contamination (Lee and Schwab, 2005).

It is observed fact that the qualities of water leaving treatment plant and water reaching consumer's end are not the same. It shows that the transmission mains, storage tanks and distribution system itself can have a negative impact on the water quality of water. Hence to safeguard the consumer, water quality standards need to be maintained throughout the distribution system (Munavalli 2002). Hence the basic water quality parameters like turbidity, free chlorine, and microbial contamination should be analyzed temporally and spatially. Proper chlorination practice should be designed as disinfection facility for water to be distributed at the consumer end.

The WDS of Miraj city is around 35 years old. The system comprises of CI, PVC, HDPE, DI, and GI. The city has an intermittent water supply. The distribution network consists of a combination of dead end and looped water supply system. There are some cases of health affect due to consumption of unhealthy supplied water from municipal facility though the outlet water quality has permissible water quality standards for drinking water. Some parts of distribution system have zero residual chlorine. This suggests that there is the vulnerability of deterioration of water quality supplied through water distribution network. Hence it is necessary to study existing Water Distribution System (WDS) of the city at some of the locations where poor water quality is observed. The varying trend is to be studied for the proposed study area and suggesting proper chlorination practice is the motive of this study.

II. MATERIAL AND METHOD

A. About study area

Miraj is a major city of Sangli district, Maharashtra at latitude 16.8165° N and longitude 74.6425° E. The city has a population of about 355,000. The city has water treatment plant with capacity 28.5 MLD which distributes water in the whole city. The city has 6 different water supply zones as shown in figure no 1 with intermittent water supply. The selected area of zone no 4 consists of Shivajinagar, Uttamnagar, Baudh Vasahat, Sathenagar is targeted as many complaints about quality (odour, taste, and color) of water. Also, in the year 2007, an outbreak of cholera and gastrointestinal disorders was reported.

B. Methodology

Existing water distribution system in whole Miraj city was studied. This study included population, water demand, water supply frequency, water supply hours of the city and

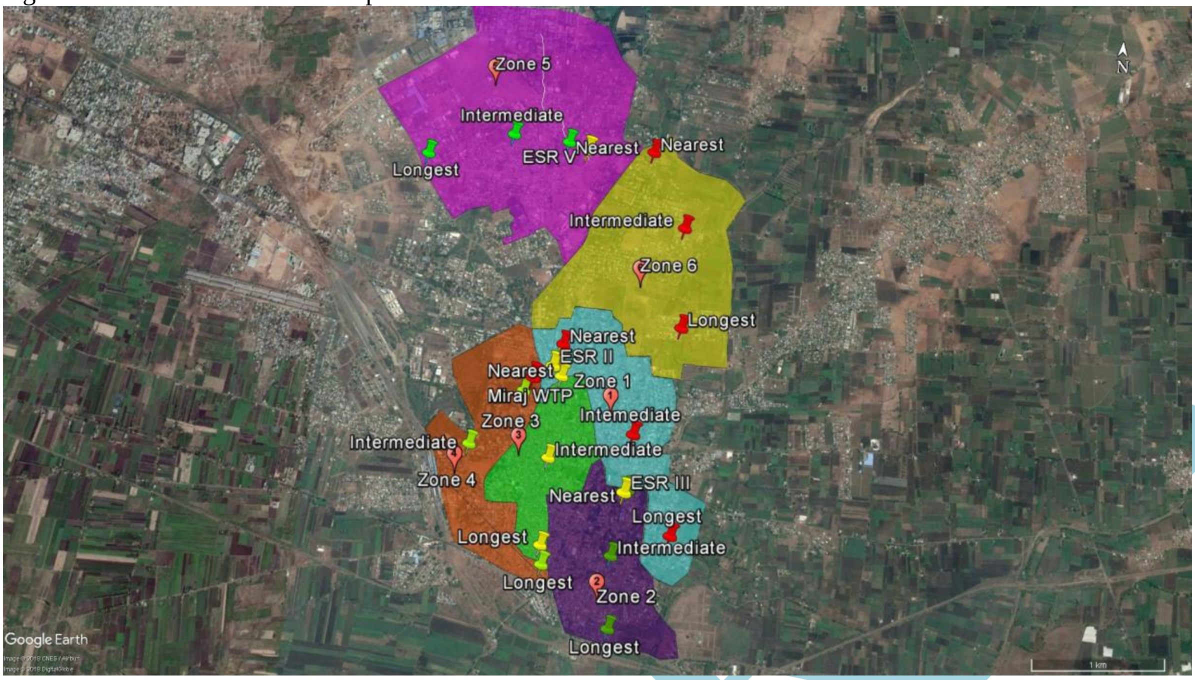


Fig 1 Water Distribution Zones in Miraj City

also age, material, diameter, lengths of pipes in existing Water Distribution System (WDS).

Figure 2 shows the target zone and sampling locations considered for water quality assessment. The representative sample from target zone in which relative portion or concentration of all parameters under consideration will be appearing and representing the quality of water sample under analysis. The samples were taken from locations that are representative of the water source, treatment plant, storage facilities, distribution network, and the points at which water is delivered to the consumer. To analyze the water supply system, a sample which is near to supply system, at an intermediate distance and farthest from supply facility was considered. The target area of zone III is having Cast Iron (CI) pipe network and water supplied between 7.30 am to 11.00 am. In zone III, as the spread is not more, the nearest point was within 100 m, the intermediate point was at 0.77 km and the longest point is at around 1.39 km from ESR I. Table 1 shows method adopted for the analysis.

Table II.1 Methods adopted for quality analysis

Sr. No	Parameters	Methods
1	Residual Chlorine	DPD Method
2	pH	Potentiometry
3	Turbidity	Nephelometry
4	Chlorides	Argentometric Titration
5	Microbial quality	Most Probable Number
6	Total Hardness	EDTA Method
7	TDS	Conductometry
8	Electric Conductivity	Conductometry

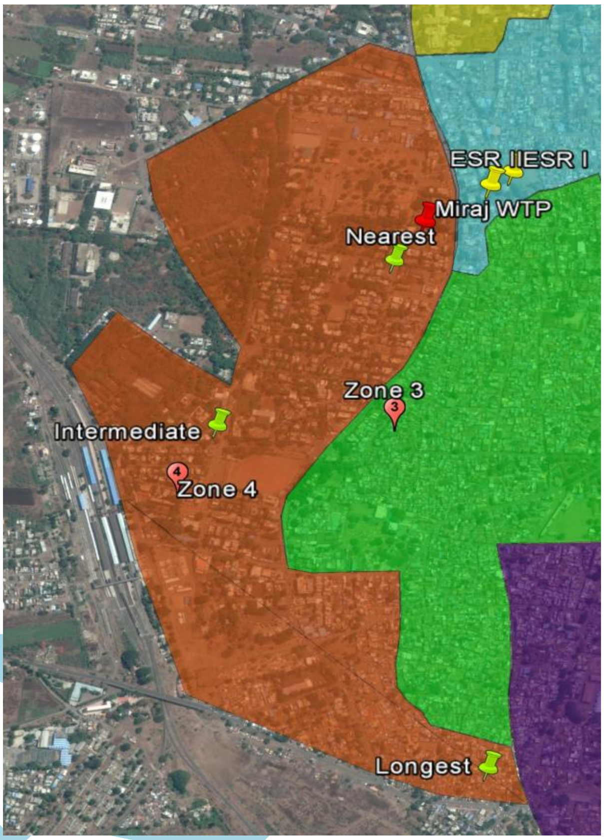


Fig 2 Targeted zone no 4 and sampling locations within the study area

III. RESULTS AND DISCUSSIONS

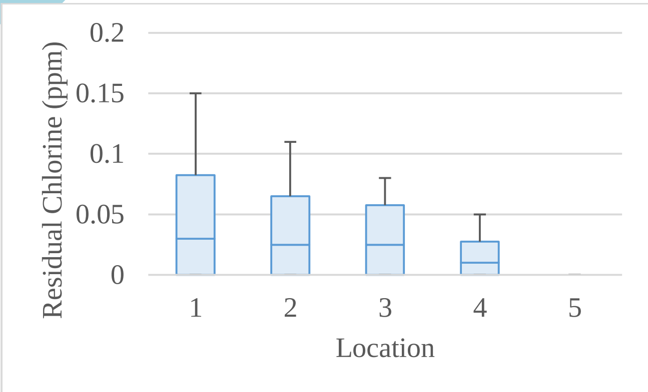


Fig 3 Residual Chlorine Variation

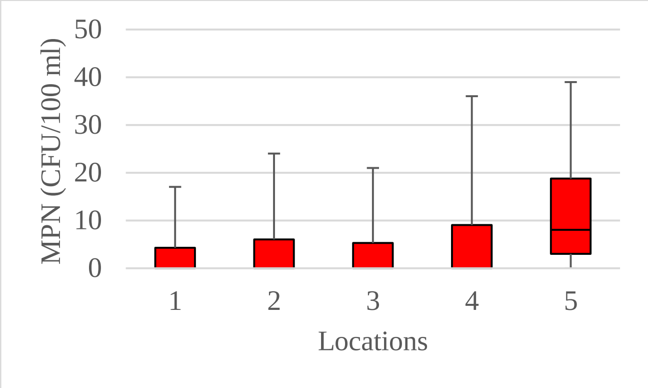


Fig 4 Bacteriological Quality Variation

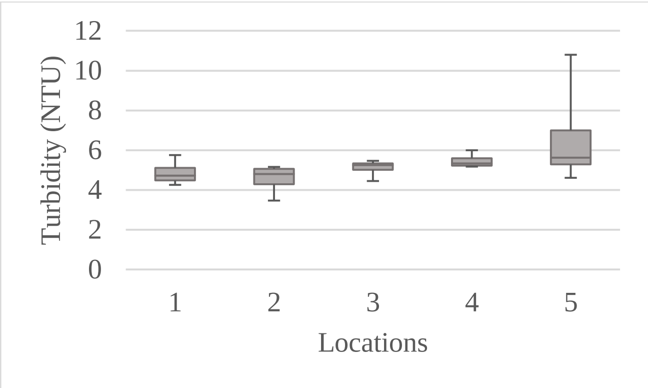


Fig 5 Turbidity Variation

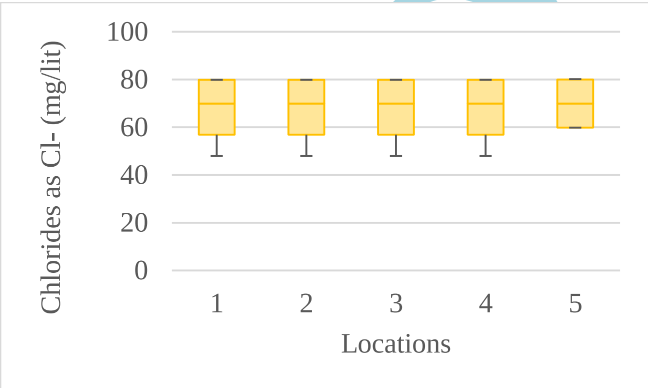


Fig 6 Chlorides Concentration Variation

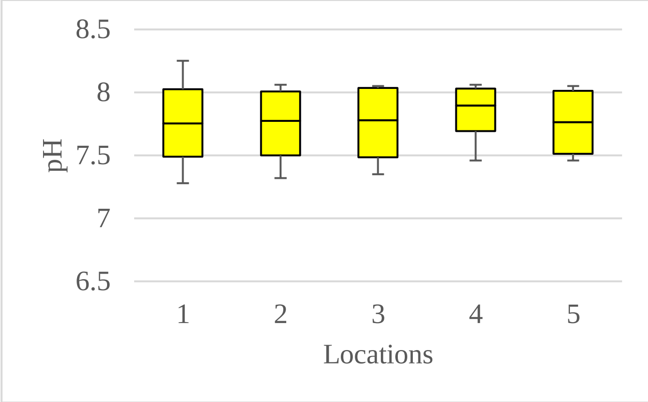


Fig 7 pH Variation

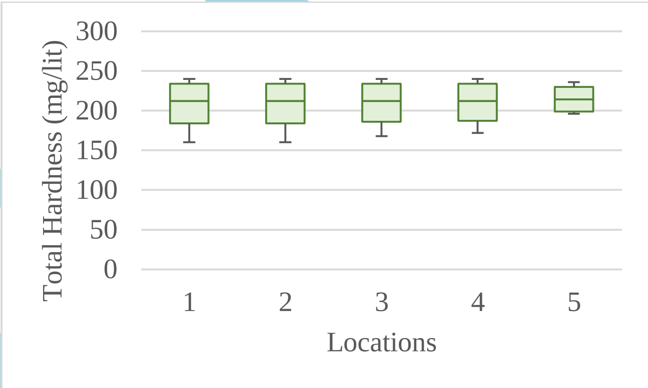


Fig 8 Total Hardness Variation

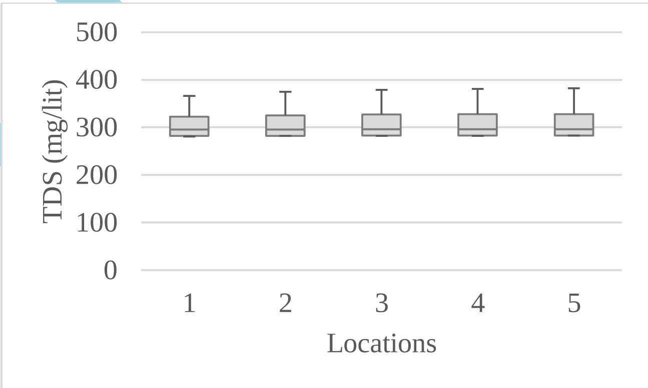
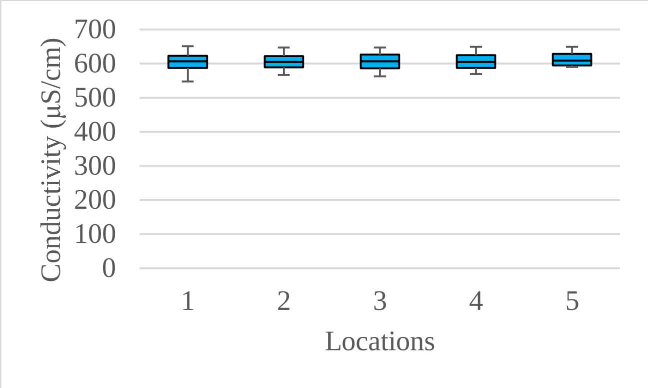


Fig 9 Total Dissolved Solids concentration Variation



Locations were 1: WTP, 2: ESR, 3: Nearest Point, 4: Intermediate Point, 5: Longest Point

Fig 10 Electric Conductivity Variationabove graphs show the variation in parameters along the distribution system from WTP to consumer end.

A. Residual Chlorine:

Fig 3 shows a trend of residual chlorine concentration in the target zone. According to WHO and IS 10500: 2012, the concentration at every location was found to be below required concentration. The graph shows declining trend of residual chlorine concentration as the water reaches up to longest point. The Maximum value observed at WTP sump was 0.15 ppm. At each sampling cycle, no chlorine was observed at the longest point of the distribution system. The possible reason for this variation is bulk and wall decay of chlorine as initial bacteriological contamination was observed at WTP sump and distribution network is around 35 years old and made up of CI pipes. Another reason was the growth of bacteria in distribution network as results for bacteriological quality shows that there was an increase in contamination level as the water reaches to longest point.

B. Bacteriological Quality:

Fig 4 shows that there is increasing trend of bacteriological contamination in the study area. The bacteriological quality of water was not complying the criteria according to IS 10500: 2012 that microbial count should not be more than zero. The average values observed were between 0 to 10 no/100ml at WTP, ESR, nearest point and the intermediate point. The maximum value obtained was 39 no /100ml at the longest point. The raised microbial count was observed at the longest point. As the value of MPN is more at the longest point than that of at WTP, it signifies the growth of bacteria in WDN.

C. Turbidity:

Fig 5 shows the increasing trend of turbidity as water traveled from WTP to consumer end. The values for turbidity were between 4 to 6 NTU at all the locations except at the longest point. The observed values were exceeding the limiting value of less than 5 NTU given by WHO and are 10500: 2012. The turbidity value increased due entrainment of corroded CI pipe which is used for the conveyance of water supplied from WTP. The raised complaints from consumers about color are mainly due to this entrainment from this pipes.

D. Chlorides:

Fig 6 shows chlorides variation in the distribution system within the target area. The value at WTP was reflected at every location in the distribution system, this shows that there was no intrusion of sewage in the distribution system. The concentration of chlorides was found to be less than 80 mg/L as Cl^-, which is less than permissible limit given by IS 10500: 2012. This suggests that the increase in the microbial count was due to the growth of bacteria in distribution system only.

E. pH:

Fig 7 shows pH variation in the target zone. At all sampling locations, pH values were between 6.5 to 8.5 that is within drinking water quality standards given by WHO and IS 10500: 2012.

F. Total Hardness, TDS and Electric Conductivity

Fig 9, Fig 10, Fig 11 shows the variation in values of total hardness, TDS and EC respectively. The total hardness value observed was below 600 mg/L as $CaCO_3$. The range observed was between 152 to 248 mg/L as $CaCO_3$. The observed value is within the acceptable limit and permissible limit given by IS 10500: 2012. The values of TDS varied between 282 to 386 mg/L. The values were below 500 mg/L and within drinking water quality standards given by IS 10500: 2012. In sampling cycles conducted between the months of October to December, it was observed that values of all the three parameters discussed above were increased significantly. The reason for this increased value is a change in water quality at source after monsoon season.

IV. CONCLUSION

The present study was conducted to assess the quality of distributed water in a part of Miraj City. From the present study, it is observed that the physicochemical quality of water is in acceptable range according to standards but the bacteriological quality is very poor. Among all the samples, 33% samples were found positive at WTP, ESR, nearest point, and intermittent point. All the samples taken from the longest point were found positive for MPN test. The reason for this result was the absence of residual chlorine at the location. All the samples analyzed for residual chlorine at longest point showed nil chlorine concentration. In every sampling cycle, at all locations, residual chlorine concentration was observed to be less than required concentration. The samples collected immediately after monsoon showed raised turbidity values at all locations. During water supply, variation in free chlorine, turbidity, bacteriological quality variation was observed in the zone. The turbidity values exceeded permissible values due to old

CI pipes used for the conveyance of water. The complaints about color were due to this turbid water when supply was first turned on. At the longest point, precautionary measures must be taken to avoid health hazards. For proper chlorination, proper chlorination model should be used to maintain specified chlorine level at all points in the distribution network.

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