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An Evaluation on Microbial Contamination in Water Supply Distribution System

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Abstract— *Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). In almost all cases the effect is damaging not only to individual species and populations, but also to the natural biological communities. All people live downstream of water supplies. Hence, the quality of water depends on the maintenance of water supply network. During the lateral travel of water it may contaminated by various microorganisms. This polluted and contaminated water affects the consumer's health and cause various water borne diseases. Therefore, in present study, the level of total coliform in water distribution network is evaluated in different areas of Calicut city. Residual chlorine and fecal coliform bacteria were also analyzed. Interestingly, it was found that residual chlorine were present in permissible limit in most of the area samples, however, showing the presence of microbes and coliforms. The area samples found to have coliform bacteria showing the possibility of contamination of water supply by sewage discharges which come in contact with supplied water due to leakage in pipes. It is possible that microbes may enter through damaged pipes. To provide good quality water to consumer, it should be protected from microbial contamination by maintaining the water supply network.*

Keywords — Residual chlorine, Coliform bacteria, Fecal coliform

1. Introduction

Water plays a vital role in human life. The most common and widespread health risk associated with drinking water is contamination. Before water can be described as potable, it has to comply with certain physical, chemical and microbial standards which are designated to ensure that the water is potable and safe for drinking. The distribution system itself must provide a secure barrier to post-treatment contamination as the water is transported to the user. The principal objective of municipal water supply is the production and the distribution of safe water that is fit for human consumption. According to the reports from World Health Organization in 2010, more than 780 million people worldwide lacked access to improved drinking water. The WHO defines "improved" drinking water sources as any sources that are "by nature of its construction or through active intervention, are protected from outside contamination, in particular from contamination with fecal matter. However, this definition does not necessarily mean that people with access to "improved" water sources are drinking safe water (i.e., water that is free of waterborne pathogens or other disease-causing contaminants). In fact, many studies have shown

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unsafe levels of bacteriological contamination in household drinking water, even when that water is supplied from an "improved" source. This contamination can be caused by any number of problems, from source water contamination, to unsanitary taps, to problems within the piped system, and problems with household storage [4], [12].

Tap water treated in water plants can be exposed to various pollutant sources before it reaches the consumer's faucet. The management of a water distribution system and a water treatment process is regarded as important to the supply of quality tap water. Even when disinfection occurs during water treatment processes, bacterial re growth may occur in the long journey through water distribution systems. Bacterial re growth in water distribution systems can occur because of the accidental entry of microorganisms at cross connections and broken pipes and the recovery of microorganism populations affected by insufficient doses of disinfectants in water treatment plants. Contamination in drinking water is manmade and usually due to improper handling, storage and serving which leads to the serious water borne diseases. The hygienic practices plays an important role in the contamination of water and the water may also become contaminated at any point between collection, storage serving or handling in houses. Microbial contamination of collected and stored household water is caused not only by the collection but also by use of unsanitary and inadequately protected water collection and storage containers. On a global scale, however, mishandling within the home is likely to be the most significant source of fouling [11].

Potable water is not sterile. Assuming water of good quality enters the distribution system, there are still numerous ways the water can be contaminated, including cross connections and back flow. Leaking pipes, joints, and valves can also allow for the entry of microbes, especially during temporary periods of negative pressure. Poorly designed or maintained finished water reservoirs and tanks can allow for recontamination if birds and other animals, including humans, have access. Because sediment can accumulate in tanks and reservoirs, providing a habitat for microorganisms, storage units can be a major focus of recontamination problems, especially in tanks where the water has long residence times [3].

No major cities in India has continuous water supply, though several cities in India have implemented pilot projects or developed proposals to switch from intermittent to continuous supply. Improved water quality is always mentioned as a benefit of upgrading an intermittent water supply to a continuous supply. Because the cost of upgrading to continuous supply may be significant, it is important to provide quantitative evidence of whether the expected water quality benefits are actually achieved to aid decision makers in identifying cost effective strategies to upgrade intermittent supplies [4].

2. Objective

The present study is intended to assess the level of microbial contamination occurring in water distribution system in Calicut city by,

1. Analyzing the source water quality in distribution system by testing water quality of distribution reservoirs considering seasonal variation.
2. Analyzing the microbial growth in piped system by evaluating the water quality of street tap water samples taken from both

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continuous and intermittent water supplied areas considering seasonal variations.

3. Analyzing the microbial growth in residential storage tank water samples taken from both continuous and intermittent water supplied areas considering seasonal variations.

3. Methodology

3.1 Analysis of microbial growth in water supply system.

Microbial contamination can be caused by any number of problems, from source water contamination, to unsanitary taps, to problems within the piped system, and problems with household storage. To understand the water quality deterioration in distribution system samples were collected from reservoirs, street taps, and drinking water provided by households and tested for total Coliform, fecal Coliform, residual chlorine, pH and turbidity. The study was first conducted on distribution reservoirs to find whether water treatment is carried out efficiently. Water quality in 5 reservoirs located at Malaparamba, Pottammel, Kovoor, Balamandiram, and Thalakkulathur are analyzed for microbial growth.

To study the microbial growth in piped system, the analysis was conducted on water samples taken from both continuous and intermittent water supply. The main reasons for contamination inside pipes are contamination due to intrusion of external material through leakages and growth of biofilm. Hence tap water samples taken from both distribution systems were analyzed for understanding water quality deterioration of tap water occurring inside pipeline.

To understand the problems associated with household storage of water, water samples were collected from storage tanks. The samples were collected and analyzed from storage tanks in location were water is supplied both continuously as well as intermittently.

3.2 Sample collection

The area selected for the study is the Calicut city, where the drinking water is supplied by Kerala Water Authority. The various reservoirs supplying water to study area were identified and samples were taken from these reservoirs for analysis. Area coming under intermittent water supply was identified and samples were collected from street taps and household storage tanks. Intermittent water supply areas selected were elevated areas in which water is obtained only during night time and those areas were water supply is regulated for a particular time using valve control. Areas having continuous water supply adjacent to intermittent zones were identified and samples were collected from both street taps and household storage tanks. Thus the samples were collected from storage reservoirs, continuous water supply and intermittent water supply systems.

3.3 Sample analysis

Water sample for enumeration of bacteria were collected in sterile glass bottles. Samples were either tested as fast as possible else kept in refrigerator before processing in laboratory. Samples were tested for total Coliform and fecal Coliform by the Most Probable Number (MPN) test, in which the samples were incubated at 37ºC and counted after 24 hours. Samples for physico-chemical analysis were collected in clean bottles and tested for turbidity and pH using turbidity meter and pH meter. Residual

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chlorine was tested on site using Ortho-Tolidine test kit.

4. Results and Discussions

4.1 Analysis of microbial contamination in distribution reservoirs

Water quality analysis was conducted on 5 reservoirs located at Malaparamba, Pottammel, Kovoor, Balamandiram, and Thalakkulathur. The selected distribution reservoirs used to supply water to required areas continuously as well as intermittently. The analysis was conducted for winter as well as summer season.

4.1.1 Analysis of microbial contamination in distribution reservoirs during winter season

Table No 1: Water quality analysis of distribution reservoirs (winter season).

source	Residual chlorine (mg/l)	Turbidity (NTU)	pH	Total coliform (MPN in 100 ml)	Fecal coliform (MPN in 100ml)
Malaparamba	0.5	2.46	7.65	4	0
Pottammel	0.6	1.98	7.37	0	0
Kovoor	0.5	1.47	7.64	0	0
Balamandiram	0.3	3.47	7.49	3	0
Thalakkulathur	0.1	4.64	7.49	15	0

4.1.2 Analysis of microbial contamination in distribution reservoirs during summer season

Table No 2: Water quality analysis of distribution reservoirs (summer season).

source	Residual chlorine (mg/l)	Turbidity (NTU)	pH	Total coliform (MPN in 100 ml)	Fecal coliform (MPN in 100ml)
Malaparamba	0.6	2.07	7.09	3	0
Pottammel	0.5	1.2	7.19	0	0
Kovoor	0.3	1.9	7.65	0	0
Balamandiram	0.2	3.53	7.44	0	0
Thalakkulathur	0.1	5.01	7.36	23	0

4.1.3 Comparison of seasonal variation of water quality in distribution reservoirs

While comparing the water quality of 5 reservoirs during winter as well as summer season, it was found that almost similar quality was maintained in both seasons. Residual chlorine concentration was observed same in both seasons. Turbidity and pH values of samples were within permissible limit in both seasons. Total coliform presence was seen in Malaparamba and Thalakkulathur reservoir in both seasons. Presence of fecal coliform was not detected in any of the samples taken in both seasons.

So it can be understood that there were no significant difference between the water supplied by various reservoirs and they maintained all quality parameters according to standards during winter and summer season. But presence of total coliform bacteria was detected at Malaparamba and Thalakkulathur reservoir. Hence it is recommended to clean both reservoir at Malaparamba and Thalakkulathur frequently during both season. The water provided by Kerala Water Authority was more or less of drinking water standards.

4.2 Analysis of microbial contamination in pipe network

For the analysis of microbial contamination in pipe network, water samples were collected and tested from continuous as well as intermittent water supply system in various places under Calicut city during winter and summer.

4.2.1 Analysis of microbial contamination in continuous water supply pipe network during winter season.

Table No 3: Water quality analysis of street taps in continuous water supply system during winter season.

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Source	Residual chlorine (mg/l)	Turbidity (NTU)	pH	Total coliform (MPN in 100ml)	Fecal coliform (MPN in 100ml)
Malaparamba	0.3	3.42	7.76	4	0
Kunduparamba	0.1	4.74	7.24	7	0
East hill	0.4	1.42	6.96	3	0
Aryadathu palam	0.4	2.54	6.97	3	0
Meenchanda	0.1	4.63	7.48	23	0
Kallai bridge	0.3	3.69	7.62	6	0
Pallikandy Francis road	0.1	3.98	7.01	12	0
Chevayoor police station	0.2	3.99	7.89	12	0
Malaparamba housing colony	0.1	4.5	7.56	21	0

4.2.2 Analysis of microbial contamination in continuous water supply pipe network during summer season.

Table No 4: Water quality analysis of street taps in continuous water supply system during summer season.

Source	Residual chlorine (mg/l)	Turbidity (NTU)	pH	Total coliform (MPN in	Fecal coliform (MPN in
Malaparamba	0.4	2.78	7.6	4	0
Kunduparamba	0.1	3.58	7.98	13	0
East hill	0.5	2.32	7.18	4	0
Aryadathu palam	0.2	4.5	7.75	12	0
Meenchanda	0.1	4.45	7.1	20	0
Kallai bridge	0.2	2.2	7.91	9	0
Pallikandy Francis road	0.1	4.1	7.37	9	0
Chevayoor police station	0.2	4.5	7.54	12	0
Malaparamba housing colony	0.1	4.44	7.93	21	0

4.2.3 Comparison of seasonal variation of water quality in continuous water supply system.

When comparing the water quality of samples taken from continuous water supply in winter as well as summer season showed almost the same quality.

Residual chlorine was observed in required concentration in all samples. Turbidity was within the limit in all the samples and all sample showed pH in the neutral range during both season. The concentration of total coliform was seen in all continuous water supply street tap samples but showed negative result in the confirmatory test for detecting fecal coliform taken in winter as well as summer season and so there was no fecal microbial contamination in continuous water supply system. When comparing the water quality of samples taken in winter as well as summer, it can be understood that there was not much significant difference in water quality in continuous water supply system when seasonal variation is considered.

The presence of total coliform was observed in all samples collected from the continuous supply during summer and winter season. The reason which contributes to microbial contamination of drinking

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water in pipe network is breakage occurring in pipes, the very old pipe network, non scoring of dead end mains, biofilm formed inside the pipe network etc

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4.2.4 Analysis of microbial contamination in intermittent water supply pipe network during winter season.

The samples required for water quality analysis was collected from street taps in which drinking water is supplied intermittently. Samples were collected from 11 sampling points. The sampling points were selected in such a manner that it is most close to the areas from which water samples are collected for analysis of continuous water supply system.

Table No 5: Water quality analysis of street taps in intermittent water supply system during winter season.

Source	Residual chlorine (mg/l)	Turbidity (NTU)	pH	Total coliform (MPN in 100ml)	Fecal coliform (MPN in 100ml)
Parambath	0.4	3.02	7.85	3	0
Puthiyangadi	0.2	3.54	7.67	6	0
Karaparamba	0.2	3.39	7.71	6	0
Chungam junction	0.2	3.4	7.78	9	0
Civil station	0.3	3.56	7.63	4	0
Thaneerpanthal	0.2	3.28	6.98	7	0
Beach road-red cross	0.1	4.46	7.65	9	0
Thondayad	0.1	4.03	7.98	15	0
Chevayoor	0.3	2.72	7.13	6	0
Thalakkulathur parambath	0	4.98	7.32	53	0
Thalakkulathur purakkattri	0	4.91	7.47	75	0

4.2.5 Analysis of microbial contamination in intermittent water supply pipe network during summer season.

Table No 6: Water quality analysis of street taps in intermittent water supply system during summer season.

Source	Residual chlorine (mg/l)	Turbidity (NTU)	pH	Total coliform (MPN in 100ml)	Fecal coliform (MPN in 100ml)
Parambath	0.3	3.02	7.24	6	0
Puthiyangadi	0.1	4.21	7.47	12	0
Karaparamba	0.4	4.5	7.19	3	0
Chungam junction	0.2	3.77	7.22	12	0
Civil station	0.2	3.86	7.15	9	0
Thaneerpanthal	0.2	3.39	7.71	9	0
Beach road-red cross	0.1	4.33	7.74	9	0
Thondayad	0.1	3.9	7.7	7	0
Chevayoor	0.2	3.4	7.84	3	0
Thalakkulathur parambath	0	3.94	7.65	44	0
Thalakkulathur purakkattri	0	4.99	7.24	64	0

4.2.6 Comparison of seasonal variation of water quality in intermittent water supply system.

Residual chlorine was observed in required concentration in all samples. When comparing the water quality of samples taken from intermittent water supply for winter as well as summer season and continuous supply of water it is understood that slight increase in turbidity was observed in intermittent supply pipe water. The increase in turbidity in intermittent water supply may be due to the intrusion of external material when pipe is empty. The pH was maintained in neutral range in all water samples. The concentration of total coliform was in all the samples and high in Thalakkulathur Parambath and Purakkattri for both winter and summer season. The fecal coliform presence was not detected in the samples taken in both seasons. It can be understood that there was not much significant difference in water quality in intermittent water supply system when seasonal variation is considered.

The first reason which contributes to microbial contamination of drinking water in pipe network is leakages occurring in pipes, which cause intrusion of external organic materials as well as dirt containing microbes into the pipes when the pipes are empty. The continuous as well as intermittent

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distribution system provided water in required quality standards. When comparing the water quality of samples taken from both intermittent as well as continuous water supply system, continuous water supplied system showed better water quality. It is to be specified that, even though distribution systems experienced several events of pipe breakages which would have lead to intrusion of external matter into pipe network; the disinfection provided was efficient enough to resist all microbial contamination occurring inside pipe. The presence of residual chlorine in all analyzed samples was the proof for the efficiency of disinfection. Hence the water supplied was of potable standards in both distribution reservoir as well as pipe network in continuous and intermittent water supply.

4.3 Analysis of microbial contamination in household storage tank.

The reason which contributes to microbial contamination of drinking water in household storage tank is mainly due to intrusion of foreign materials inside storage tank as well as exorbitant growth of micro organism present in stored water. For the analysis of microbial contamination in storage tank, water samples were collected and tested from continuous as well as intermittent water supply system in various places under Calicut city. The analysis was carried out by collecting and testing water samples from domestic water storage tanks in households. The analysis was carried out in winter and summer season.

4.3.1 Analysis of microbial contamination in continuous water supply - household storage tanks during winter season

Table No 7: Water quality analysis of household storage tanks in continuous water supply in winter season

Source	Residual chlorine (mg/l)	Turbidity (NTU)	pH	Total coliform (MPN in 100ml)	Fecal coliform (MPN in 100ml)
Malaparamba	0	5.87	7.56	23	0
Kunduparamba	0	5.45	7.4	14	3
East hill	0.3	3.18	7.84	4	0
Aryadathu palam	0.1	3.86	7.48	14	0
Meenchanda	0	5.85	7.66	29	3
Kallai bridge	0.1	5.05	7.75	9	0
Pallikandy Francis road	0	4.56	7.87	44	4
Chevayoor police station	0	4.91	7.84	34	3
Malaparamba housing colony	0	4.76	8.22	28	0

4.3.2 Analysis of microbial contamination in continuous water supply - household storage tanks during summer season

Table No 8: Water quality analysis of household storage tanks in continuous water supply in summer season

Source	Residual chlorine (mg/l)	Turbidity (NTU)	pH	Total coliform (MPN in 100ml)	Fecal coliform (MPN in 100ml)
Malaparamba	0.1	4.53	7.92	39	0
Kunduparamba	0	4.22	7.61	19	0
East hill	0.4	2.99	7.24	7	0
Aryadathu palam	0	5.06	7.84	20	0
Meenchanda	0	5	7.46	26	1
Kallai bridge	0.1	4.54	7.28	24	0
Pallikandy Francis road	0	4.98	7.21	24	3
Chevayoor police station	0.1	5.66	7.76	34	3
Malaparamba housing colony	0	4.96	7.17	26	0

4.3.3 Comparison of seasonal variation of water quality in continuous water supply - household storage tanks

The samples taken from Kunduparamba, Meenchanda, Pallikandy francis road and

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Malaparamba housing colony showed absence of residual chlorine in winter and summer season. The water quality analysis conducted on samples taken from household storage tanks in continuous water supply in winter as well as summer season showed turbidity beyond permissible in sample collected from Meenchanda in both seasons. The microbial analysis conducted on water samples during both season, showed presence of total coliform. But during confirmatory test, only samples from Meenchanda, Pallikandy Francis road, and Malaparamba housing colony showed presence of fecal coliform in both season. Increase in microbial growth was seen in samples were residual chlorine concentration was absent.

The absence of residual chlorine and frequent cleaning of household storage tank may be the reason for microbial contamination occurring in stored water. Water stored in continuous water supply system was more contaminated than sample from taps. Most households with continuous water supply continued to store water and therefore were not realizing the full water quality of continuous water supply.

4.3.4 Analysis of microbial contamination in intermittent water supply - household storage tanks during winter season.

Table No 9: Water quality analysis of household storage tanks in intermittent water supply in winter season

Source	Residual chlorine (mg/l)	Turbidity (NTU)	pH	Total coliform (MPN in 100ml)	Fecal coliform (MPN in 100ml)
Parambath	0.1	4.77	7.04	9	0
Puthiyangadi	0	4.8	7.89	11	0
Karaparamba	0	4.43	7.24	9	3
Chungam junction	0	4.52	7.19	12	0
Civil station	0	5.66	7.52	6	0
Thaneerpanthal	0.1	3.6	6.97	9	0
Beach road-red cross	0	5.22	7.95	20	12
Thondayad	0	4.98	7.88	23	0
Chevayoor	0.2	3.77	7.9	11	0
Thalakkulathur parambath	0	5.29	7.61	64	0
Thalakkulathur purakkattri	0	5.15	7.6	93	0

4.3.5 Analysis of microbial contamination in intermittent water supply - household storage tanks during summer season

Table No 10: Water quality analysis of household storage tanks in intermittent water supply in summer season.

Source	Residual chlorine (mg/l)	Turbidity (NTU)	pH	Total coliform (MPN in 100ml)	Fecal coliform (MPN in 100ml)
Parambath	0	4.55	7.52	12	0
Puthiyangadi	0	4.74	7.63	19	0
Karaparamba	0.1	4.63	7.41	9	0
Chungam junction	0.1	3.69	7.18	15	0
Civil station	0	4.91	7.49	12	0
Thaneerpanthal	0.1	3.79	7.84	13	0
Beach road-red cross	0	5.45	7.65	26	4
Thondayad	0	4.88	7.84	14	0
Chevayoor	0.1	4.68	7.76	19	0
Thalakkulathur parambath	0	4.88	7.34	75	0
Thalakkulathur purakkattri	0	5.45	7.52	93	1

4.3.6 Comparison of seasonal variation of water quality in intermittent water supply - household storage tanks.

The minimum required concentration of residual chlorine was observed in almost all samples. Some of the samples even showed absence of residual chlorine. The water quality of samples taken from household storage tanks in intermittent water supply in winter as well as summer showed turbidity beyond permissible in samples collected from Beach

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road-red cross and Thalakkulathur Purakkattri. All water samples tested showed pH in neutral range.

The microbial analysis conducted on water samples showed presence of total coliform in all water samples in both seasons. During confirmatory test, the sample collected from Beach road-red cross showed positive in both season. It has to be noted that increase in microbial growth was seen in samples were residual chlorine concentration was absent.

When comparing the overall water quality in distribution reservoir, pipe network and storage water it is proved that the quality of water inside distribution reservoir was maintained at required water standards. The analysis conducted on continuous and intermittent supply proved that the supplied water was also free from fecal coliform contamination. Even though many cases of leakages were reported in pipe network, the presence of residual chlorine water quality in required drinking standards. So microbial contamination of water was observed only in household storage tanks. The consumers may be educated towards the cleaning of storage tank frequently and disinfect it.

4.4 Water quality analysis of areas which showed fecal coliform presence in storage tanks.

The water quality analysis conducted at several places in Calicut city showed the presence of fecal coliform .Water samples taken from storage tanks located at Meenchanda, Pallikandy Francis road, Chevayoor police station and beach road-red cross areas were showing presence of fecal coliform in both season. Hence detailed microbial analysis of water in these areas alone was carried out by taking several samples from this area. A total of 4 samples including the sample which was taken previously were collected for detailed analysis.

Fecal Coliform contamination was observed in samples where proper hygiene was not maintained in storing water. The top cover of tanks had cracks at those sites which caused chances of intrusion of bird droppings. In other cases water were taken from these tanks by dipping vessel for various purposes. In this case contamination can occur by water coming in contact with contaminated hand or by vessel itself.

4.5 Analysis on effect of temperature on residual chlorine degradation

The residual chlorine concentration and temperature of the water inside exposed tank was measured during intervals of 2 hours and was tabulated as follows.

Table No 15: Residual Chlorine concentration in exposed water tank

Sl No	Time	Temperature (°C)	Residual Chlorine (mg/l)
1	6:00 AM	26	5
2	8:00 AM	28	3
3	10:00 AM	32	0.8
4	12.00 PM	39	0.5
5	2.00 PM	39	0.1
6	4.00 PM	36	0.1
7	6.00 PM	35	0

The residual chlorine concentration and temperature of the water inside covered water tank was measured during intervals of 2 hours and was tabulated as follows.

Table No 16: Residual Chlorine concentration in covered water tank

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Sl No	Time	Temperature (°C)	Residual Chlorine (mg/l)
1	6:00 AM	26	5
2	8:00 AM	28	3
3	10:00 AM	32	2
4	12.00 PM	39	2
5	2.00 PM	39	2
6	4.00 PM	36	1
7	6.00 PM	35	1

It was observed that the residual chlorine was completely exhausted in exposed water tank after 12 hours but the covered tank retained residual chlorine even after 12 hours.

One of the reasons for low residual chlorine in household storage tanks are due to the outside temperature variation which enhances faster biological process and chemical reactions.

5. Conclusion

I. There were no significant difference between the water supplied by various reservoirs and they maintained all quality parameters according to standards during winter and summer season.

II. The continuous water supply network provided water at consumer taps that were less frequently contaminated and had lower concentrations of indicator bacteria than intermittent water supply.

- ✓ Residual Chlorine in required standard was observed in samples taken from taps in both intermittent water supply and continuous water supply.
- ✓ More turbidity was observed in intermittent water supply than continuous water supply system may be due to intrusion.
- ✓ In many sample, even though the MPN of Total coliform was beyond permissible limit there was no presence of fecal coliform during confirmatory test.

(The major species of Coliform bacteria seen was *Enterobacter spp* which belong to non fecal coliform).

- ✓ Intermittent water supply provided water quality similar to continuous water supply system in some cases.

III. Water stored in both intermittent water supply and continuous water supply households was more contaminated than tap water.

- ➢ Water stored in intermittent water supply was more contaminated than water stored in continuous water supply.
- ➢ Residual Chlorine degradation was observed in all storage tanks in both network and the rate of degradation was observed directly proportional to the temperature rise of stored water
- ➢ Most households with continuous water supply continued to store water and therefore were not realizing the full water quality of continuous water supply.

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The detailed study conducted on water distribution system in Calicut city proved that even though drinking water was supplied to the reservoir meet the required water quality standards, the breakage of distribution network, non cleaning of reservoir, non scouring of pipelines, unhygienic practices of storing water etc had lead to microbial contamination of water kept inside household storage tanks.

References

1. Ameer Shaheed, Jennifer Orgill and Joe Brown, "*Why "improved" water sources are not always safe*?" Bulletin of World Health Organization, 92(4), 2014, pp.283-289.
2. Andey, Subhash P.; Kelkar, Prakash S, "*Performance of Water Distribution Systems During Intermittent Versus Continuous Water Supply*", Journal of American water works association, 99, 2007, pp. 99-106.
3. Deborah Alexandra Vacs Renwick, "*The effects of an intermittent piped water network and storage practices on household water quality in tamale, Ghana*", Massachusetts Institute of Technology, 2013.
4. Emily Kumpel, Kara L. Nelson, 2013, "*Comparing microbial water quality in an intermittent and continuous piped water supply*", Water research 47 ELSEVIER, PP.5176-5188.
5. Emily Kumpel and Kara L. Nelson, *Environmental science and technology*, 48 (5), 2014, pp.2766–2775.
6. Helena M. Ramos, D. Loureiro, A. Lopes, C. Fernandas, D. Covas, L. F. Reis, M. C. Cunha, "*Evaluation of chlorine decay in drinking water systems for different flow conditions*", Water resources management March 2010, Volume 24, Issue 4, pp.815-834.
7. Julius Ecuru, James Okot-Okumu, Tom O Okurut, "*Monitoring residual chlorine decay and coliform contamination in water distribution network of Kampala, Uganda*", Journal of applied sciences and environmental management Vol. 15, 2011, pp.167-173.
8. Liangxin Fan, Guobin Liu mail and Fei Wang, "*Factors affecting domestic water consumption in rural households upon access to improved water supply*", Insights from the Wei River Basin, China, 2013.
9. Neha Bhatnagar1, Shweta Kulshreshtha, Pradeep Bhatnagar, "*Microbiological analysis of chlorinated water supplied in Jaipur*", Universal journal of environmental research and technology, Volume 2, Issue 2, 2012, pp.65-71.
10. N.S. Raju.C. Roopavathi K. Ramachandra kini, "*Assessment of Coliform contamination in drinking water from source to point of use in Mysore city of Karnataka, India*", 2011, pp.1047.
11. Pat McCool, "*Summer challenge of chlorine residuals: concentrate on tanks- The Kansas life line*", 2008.
12. Patrick Asamoah Sakyi and Roland Asare, "*Impact of temperature on bacterial growth and survival in drinking-water pipes*", research journal of environmental and earth sciences 4(8), ISSN: 2041-0492, 2012, pp.807-817.
13. Patrick Asamoah Sakyi, Roland Asare, Chris Anani, Samuel Boakye Dampare, "*Nutrient-Induced Growth of Coliform and HPC Bacteria in Drinking-Water Pipes*", Journal of Environmental Protection, 3, 2012, pp.508-517.
14. Philipp Klingel & Franz Nestmann, "*From intermittent to continuous water distribution: A proposed conceptual approach and a case study*

of Béni Abbès (Algeria)", Urban Water Journal Volume 11, Issue 3, 2014, pp.240-251.

15. Pierre Payment and Will Robertson, "*Safe Piped Water: Managing Microbial Water Quality in Piped Distribution Systems*", World Health Organization, ISBN: 1 84339 039 6, 2004.

16. Randi H. Brazeau and Marc A. Edwards, "*Role of hot water system design on factor influential to pathogen regrowth: temperature, chlorine residual, Hydrogen evolution, and sediment*", Environmental engineering science, October 2013, pp.617-627.

17. Robert M. Clark, Y. Jeffrey Yang, Christopher Impellitteri, Roy C. Haught, Donald Schupp, Srinivas Panguluri and E. Radha Krishnan, "*Controlling disinfection residual losses in drinking water distribution systems*", results from experimental studies, Proceedings of the 1^{0th}Annual Water Distribution Systems Analysis Conference WDSA2008.

18. Rutvan Gohil, "*Continuous water supply system against existing Intermittent Supply system*" International Journal for Scientific Research & Development| Vol. 1, Issue 2, 2013.

19. "*Health Risks from Microbial Growth and Biofilm in Drinking Water Distribution System*", United States Environmental Protection Agency, 2002.

20. Yoonjin Lee, "*An Evaluation of Microbial and Chemical Contamination Sources Related to the Deterioration of Tap Water Quality in the Household Water Supply System*", International Journal of Environmental Research and Public Health ISSN 1660-4601, 2013, pp.4143-4160.

