Abstract

Microbial contamination of drinking water is the major reason for prevalence of diarrheal disease. This study assessed both microbial and chemical contamination of Community Water supply wells (CW) from November 2009 to December 2010. To analyze the seasonal and spatial variations, monthly sampling was done. In order to identify the risk of diarrheal prevalence the study also surveyed 290 households and gathered information on household water storage, symptoms of diarrhea. Drinking water samples were collected from the household and analysed for E. coli contamination as it is the main indicator of microbial contamination. Community water and purchased water samples showed high microbial contamination. Standard spread plate method were used to enumerate the total coliform and E. coli. Pathogenic organism were isolated and identified from CW3, CW4 and CW5. The enumeration of E coli ranges from 19-60 cfu/ml in pre monsoon, 7-150 cfu/ml in post monsoon season, Faecal streptococci ranges from 0-33cfu/ml and 11-55 cfu/ml in pre and post monsoon respectively. Vibrio sp. is observed only in post monsoon season for the community water supply well. Diarrheal prevalence is comparatively high in community water sources and purchased water consumer than in groundwater consumers. To protect public health routine monitoring and disinfection of ground water for the portable use should be implemented in all the suburban areas.

Keywords: Community Water, Diarrhea, E. Coli, Suburban

1. Introduction

Urbanisation places a burden on water management systems and providing basic sanitation services. Most of the urban peri-urban areas are dependent on ground water for their drinking water but its quality remains an issue. Microbiological contamination of drinking water and inadequate sanitation can lead to large waterborne disease outbreaks. Urbanisation leads to over exploitation of water resource, congestion in water supply, drainage system, sewage disposal practices and onsite sanitation systems. The rate of depletion of ground water levels and deterioration of ground water quality is of immediate concern in major cities and towns of our country.

Usage of onsite sanitation system is common in urban and suburban areas of developing countries; it is increasingly adopted in urban cities in India. The adoption of on-site sanitation system endangers groundwater resources and the human health at a greater risk. The contaminants are transported through the aquifers and ultimately get in contact with the groundwater. Groundwater sources are more vulnerable to nitrate contamination near on-site sanitation systems. The sitting and continued use of the solid waste disposal site in Perungudi, in the midst of the suburbs, caused further degradation of the environment and pose concerns for water quality and community health.

Unhygienic household sanitation and unsafe environmental waste disposal, household water storage practices leads to the occurrence of waterborne diseases and consign children at risk of illness and or death. More than half of the reported waterborne disease outbreaks have been linked to contaminated drinking water. Intake of contaminated water due to the lack of hygienic practices and sanitation contributes to about 1.5 million

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child deaths and around 88% of them suffer from diarrhea per year\(^9\). Storage for longer duration and handling of water at home increases the chances of contamination\(^8\). Type of storage vessel, mouth size, design and material of the vessel are also important factors found playing a major role in maintaining the quality of water during the storage in the domestic domain\(^11,12\).

Improving the microbiological quality at source and the point-of-use treatment and safe storage methods may reduce diarrhea and other water-borne diseases in communities and households. Knowledge and attitude of the people for the water usage, water handling and personal hygiene are the important factors impacting on health\(^13\). This study analyzed the link between quality of different water sources and diarrheal cases. Microbial contamination of drinking water during storage in household is the prime reason for the diarrheal prevalence in the developing country. To assess the microbial contamination in household stored drinking water and its implication on health, particularly diarrhea. This paper investigates the extent of microbial contamination of community water supply and household storage.

2. **Materials and Methods**

2.1 Study Area

Pallikaranai is located in southern part of Chennai Metropolitan Area (CMA) the study area is located between latitudes 12°54’44’’N to 12°59’0”N latitudes and 80°11’41’’E to 80°13’59”E longitude covering an areas of 17.36 sq km. It is bounded by Bay of Bengal in the North and West Kanchipuramdistrict in the south. The various sources of water are community water supply, bore well, open well, hand pump and can water (purchased water). Nearly half of the households depend on purchased water (can) for drinking. The dependency of tanker lorry water supply and the public hand pump were comparatively less.

2.2 Sampling

To assess the microbial contamination of drinking water, the samples have been collected from 7 source wells (CW1, CW2, CW3, CW4, CW5, CW6, CW7) for the period of one year from November 2009-December 2010. 1L of water sample collected in a sterile 500 mL glass bottle from the community wells. Samples were immediately transported to laboratory at 4°C in the icebox.

Sample size of 290 households from the study area was selected based on stratified randomly sampling. As per 2001 census, there are 15 wards in Pallikaranai. Each ward has household ranging from 75–450, a list of streets in all the wards and their household was collected from panchayat office. From the 15 wards 20 household having children in the age group 0–5 and 6-12 years were selected. Samples of stored water were collected from the houses enrolled in the study. The household samples were, categorized into groundwater, purchased water and community water.

2.3 Questionnaire Survey

The questionnaire was administered from April 2010-May 2011 orally to the respondents, mostly housewives during the above and recorded. The mode of questionnaire administration was face to-face interview with their mothers; relevant information about the child in the family was obtained from the respondent using a pretested structured questionnaire in the local language.

2.4 Microbial Analysis

*Faecal streptococci, E. coli, Vibrio, Salmonella and Pseudomonas* were isolated and enumerated by spread plate method for community well sample. Household storage samples were analyzed for *E. coli* alone as it is the main indicator organism.

*E. coli* was enumerated by placing an aliquot of 1 mL onto Petri films for *E. coli/Coliform Colony Count*. The plates were then incubated for 48 hours at 37°C. Blue coloured colonies with gas entrapment on EMB – plates were presumed to be *E. coli*. *Faecal streptococci* were enumerated by spread plate method 15 mL of Slandez agar were poured on to sterile petri plate and 0.5 mL of sample were pipetted out on the surface of solidified agar slowly and spread it by using L rod, invert the plate and incubate it for 48 hours at 35 °C. *Vibrio sp.* were enumerated by spread plate method 15 mL of Thiosulfate-Citrate-Bile-Sucrose agar (TCBS) was used for the primary isolates of other microorganisms, incubated for 24 hours at 37 °C, and biochemical test were performed by using Hi media specific kit for *Vibrio sp.* (Kb007).
3. Results and Discussion

3.1 Community Water Supply

Figure 1 shows the average concentration of EC, TDS and chloride in pre and post monsoon seasons. Estimated EC, TDS and chlorides are in the range of 661-1738 µS/cm, 390-1007 mg/L and 164-344 mg/L respectively. According to BIS and WHO standards, EC and TDS shall not exceed the desirable limit of 500 mg/L but within the maximum permissible limit of 2000 mg/L. The concentration of all the parameters was observed to be high in pre monsoon and comparatively low in post monsoon season. One possible reason for the uniform pattern of improvement of ground water quality during post monsoon season may be the location of these wells, either inside the lake/eri or adjoining them. Therefore the direct influence of recharge from these freshwater lakes into the shallow aquifer may have had a significant role on the water quality.

Figure 1. The average concentrations of EC, TDS, chloride in pre and post monsoon seasons of community water supply wells (n=35).

Table 1 shows mean variation of pH, turbidity, Nitrate, EC, TDS and chloride in drinking water sources. In the present study, pH values for all the samples were well within the allowable range (6.2-8.7). Turbidity ranges from 0.1-3.31, 0.68-2.7, 0.15-3.66 NTU in community water supply, groundwater and purchased water respectively. The range of Nitrate for all the samples were from 0.1-26mg/L, the highest range was recorded in community water supply. TDS and EC have a linear relationship and EC increases with increase in TDS, the highest range of TDS and EC was observed in ground water from 92-4500 mg/L and 218 to 8820µS/cm respectively. EC values exceed 2000 µS/cm in the groundwater source resulting in laxative effects to the consumers. High EC and TDS concentrations are the main indicators of dissolved inorganic ions and the degree of mineralization in the groundwater. Chloride ranges from 5-2869 mg/L. The concentration of TDS is comparatively high in community water supply than in purchased water and ground water. However nearly 44% of TDS values are within the desirable limit in community water supply, 25% of TDS values in groundwater are within the limits and in purchased water 49% of samples were within desirable limit 500 mg/L in the samples. The concentration of EC, TDS and chloride were more or less similar in community water supply and purchased water.

3.2 Microbiology

Since all the community wells are shallow, during post monsoon season microbial contamination is high, the enumeration of indicator organism TC and FC ranges from 93-1100 MPN/100 ml and 45-460 MPN/100 ml respectively.
respectively. During pre monsoon season the value ranges from 9-20 MPN/100ml and 4-15 MPN/100ml respectively as shown in Figure 2.

![Figure 2](image2.png)

**Figure 2.** Average concentration of community water supply wells TC and FC in pre and post monsoon seasons.

The enumeration of *E. coli* ranges from 19-60 cfu/mL in pre monsoon, 7-150 cfu/mL in post monsoon season, *Faecal streptococci* ranges from 0-33 cfu/mL and 11-55 cfu/mL in pre and post monsoon respectively. *Vibrio* sp. is observed only in post monsoon season. According to WHO standards, no *coliforms* should be detected in the ground water which is used for drinking purposes, because *coliform* is the indication of recent contamination of faecal matters. Among all the wells Chitteri (CW3) was found to be highly polluted.

![Figure 3](image3.png)

**Figure 3.** Seasonal Variation of *E. coli*, *Faecal streptococci* and *Vibrio* of community water supply wells.

Table 2. Isolation and identification of organism Biochemical test kit Kb002

| Test for Gram Negative Rod | *Salmonella choleraesuis subspecies cholerasuis* | *Klebsiella pneumonia* | *Enterobactoraerogenes* |
|---------------------------|---------------------------------------------|------------------------|-------------------------|
| Citrate utilisation       | +                                           | -                      | +                       |
| Lysine utilization        | +                                           | -                      | +                       |
| Ornithine utilization     | +                                           | -                      | +                       |
| TDA                       | -                                           | -                      | -                       |
| Urease                    | -                                           | -                      | -                       |
| Nitrate reduction         | +                                           | +                      | +                       |
| H₂S production            | +                                           | -                      | -                       |
| Glucose                   | +                                           | +                      | +                       |
| Adonitol                  | -                                           | +                      | +                       |
| Lactose                   | -                                           | -                      | +                       |
| Arabinose                 | +                                           | +                      | +                       |
| Sorbitol                  | +                                           | +                      | +                       |
These media may be useful for increasing the probability of isolation of *V. cholerae* from aquatic environment.

Table 3. Isolation and identification of vibrio Biochemical test kit Kb007

| Test for Vibrio spp. | Vibrio (yellow color) cholera | Vibrio proteolyticus | V. vulnificus |
|---------------------|-------------------------------|----------------------|--------------|
| VogesProskauer      | +                             | +                    | -            |
| Arginine utilization| -                             | +                    | -            |
| Salt tolerance(1%)  | +                             | +                    | +            |
| Onpg                | +                             | nd                   | +            |
| Citrate             | v                             | +                    | +            |
| Ornithine utilization| +                            | +                    | +            |
| Mannitol            | +                             | +                    | v            |
| Arabinose           | -                             | -                    | -            |
| Sucrose             | +                             | -                    | v            |
| Glucose             | +                             | +                    | +            |
| Salcin              | -                             | -                    | +            |
| Cellobiose          | -                             | -                    | +            |

V- variable 11-89%, nd - not detected

3.3 Sources of Contamination

The distance between septic tank and well were estimated in meter. 31.7% of well were less than 15m distance (the commonly used guideline is that the distance should be at least 15m). About 9% were estimated to be at a distance between 16 to 30 m from the septic tank and 14% of the well were in the distance of >30m as shown in Table 4. About 12% of the household are connected to the latrine sewage to the unlined septic tank, 54.8% of the household connected to a proper lined septic tank.

Table 4. Frequency distribution of distance between septic tank and well

| Distance between septic tank and well | Frequency | Percent |
|-------------------------------------|----------|---------|
| 0 - 15                              | 92       | 31.7    |
| 16 - 30                             | 26       | 8.9     |
| >30                                 | 41       | 14.1    |
| 5                                   | 1        | 0.3     |
| Total                               | 160      | 55.1    |
| Not Applicable                      | 130      | 44.8    |

n = 290

Table 5 illustrates the risk estimation of E. coli contamination in groundwater and its relation with distance between septic tank and well. The relative risk of E. coli greater than 30 cfu/ml is 1.2 times higher than the group less than 30 cfu/ml, which reveals that as the distance between septic tank and well decreases the concentration
of E. coli increases. Distance between septic tank and well is inversely proportional to E. coli contamination. According to World Health Organization guidelines, E. coli or Thermotolerant coliform bacteria should not be detectable in any water intended for drinking. The results indicate that the coliforms migrated from fecal matter in the septic tank through the soil to the water table, this was facilitated by the very short distance between the septic tank and well or there may be leakages from the septic tank or the septic tank may be unlined. Poor sanitary practices (open defecation).

3.4 Discussion
This study identifies fecal contamination of community water supplies both at source and during household storage in a suburban area of Chennai. The water supply is obtained from a ground and purchased water. From the results reported, the community water supply was contaminated by pathogenic organisms such as V. cholerae, V. vulnificus, V. proteolyticus, salmonella. The concentration of all bacterial parameters was observed to be high in post monsoon and comparatively low in pre monsoon season. Since all the community wells are shallow well. Vibrio cholera was observed in CW2, CW3, and CW4 wells during post monsoon season.

The concentration of TDS is comparatively high in community water supply than in purchased water and ground water which is coincide with the E. coli contamination also high in community water supply. The rate of occurrence of diarrhea were high in the households using the community water supply, the data also suggests that contamination of drinking water during storage in household vessels is the major reason for disease transmission. Using narrow-mouthed storage vessels and point of use water treatment before storage can reduce this risk as reported by. The previous part of the study observed the microbial pathogenic organisms in the community water supply well (source water), multiplies at the point of distribution and at the point of use. The major factor contributing to the contamination may be due to intermittent supply, as reported elsewhere also, stagnation of sullage waste along the pipeline, breaking of pipeline, and possible biofilm formation in water distribution pipeline.

4. Conclusion
The interdisciplinary approach of the study helps to explore and discuss the problems associated with ADD and its environmental relations. The results clearly indicate that the prevalence of diarrhea among children is mainly due to the consumption of microbial contaminated water. Sources of contamination for community water supply are anthropogenic activities and supplying water without proper chlorination. Poor handling of water while storage and for ground water the presence of E. coli due to inadequate distance between septic tank and well. Survival of Escherichia coli in water indicates recent contamination of the water source with fecal matter and hence possibility of presence of intestinal pathogens in the well. Continuous monitoring of well water quality and inspecting well sanitation helps to identify the source and route of contamination which aids to take corrective action. Household storage water is more contaminated than the community water, indicating that interventions are needed to decrease the contamination of water at household storage. Continuous monitoring of water supply by corporation may be unsuccessful in some circumstances; improving personal hygiene in handling and storage of water in domestic domain is the appropriate measures to reduce the ADD prevalence.

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