Urbanisation and Drinking Water Security in Chennai City

[a]Soorya Vennila, [a]K. Ramesh
[a]Assistant Professor, Anna University, Chennai – 600 025, Tamil Nadu, India

Abstract

Roughly every time the clock strikes there is another mouth to be fed and taken care of especially with the vital needs like water and shelter to the poor not only in rural areas but also in urban metropolitan cities of the developing countries. The present study aimed at answering two central questions: How safe drinking water in urban areas is? And how effective service delivery of drinking water is to the end-users? Chennai one of the four Metropolitan cities of India was selected for the study. As objectives, the study by way of capturing the options of people for the sources of drinking and its impact on health attempted to explore the status of service delivery of drinking water also. Finally it was inferred that there was a higher preference for packaged water available for Rs. 25-75 every twenty liters than the other water sources in urban households, on contrary the preference of people in the institutional environment was public water supply which is free and portable. Results of water quality tests and service delivery of public water supply system brought out the fact that the samples of all sources of water and the service provided were not matching the standards of safety prescribed which resulted in fatal consequences.

KEYWORDS: Drinking Water, Health, Service delivery, urban areas, Water quality

Introduction

Water has always been an important and life-sustaining drink to all living beings. It is rather difficult to imagine well being of life without access to safe drinking water. Water sources without pollution are becoming increasingly scarce today and the drinking water crisis is looming, especially in urban centres. Water has become a scarce natural and economic resource, and even a crucial strategic resource. Tu et al. (2007) suggested that, urbanized watersheds with high population density, high percentage of developed land use and low per capita developed land use have high concentration of water pollutants. The impact of urbanisation on water quality is attributed to the combined effects of population growth and land-use changes.

It is expected that by around 2020, India will be a “Water Stressed” country with per capita availability declining to 1600 cu m/year. Urbanization and population explosion have exerted diverse stress on this shrinking amount of available water resources. Particularly cities, which are engines of growth, are under great strain to meet the growing demands and aspirations of its people exerting considerable pressure on urban utilities. Providing safe and adequate drinking water to the burgeoning urban population continues to be one of the major challenges and most countries in the developing world face a daunting task in their attempts to provide effective and equitable public services.

Materials and Methods

Six pilot study areas in the urban and peri-urban regions of Chennai city are shown in Fig 1. The following is a brief description of the pilot areas:

1. Kovilambakkam, is a village panchayat (local governing body) coming under St.Thomas Block. It is located at the longitude of 80.2 and latitude of 12.9. Figure.2 shows the land use map of Kovilambakkam and its surrounding watershed region.

2. Chennai Central Railway Station is located at Park town. It is functioning since 1873 and is used by more than 1 lakh population per day. 3. Chennai Corporation Higher Secondary School which is located in West Mambalam, comes under the control of Chennai Corporation with 695 students including 241 girls and 30 working staff. 4. Chennai Mofusil Bus Terminus is located in the periphery of the city at Koyambedu. Each day 2000 buses arrive and depart and about 1 lakh people use the terminus. 5. Corporate Office, a government corporate office building consisting of 9 floors with 1126 working staff is located in Saidapet Zone. 6. Rajiv Gandhi Government General Hospital (RGGGH) constructed at the cost of Rs. 104 crores is located at Park Town. CMWSSB supplies 2 Lakh litres of water per day to this hospital which is stored in overhead Tanks (OHT) within the hospital premises.

The present study while analysing the preference for and safety of drinking water, attempts to unravel the functioning efficiency in terms of continuity and adequacy and to suggest ways to keep the local water sources intact for sustainability. The Framework of Methodology for the study is given in Flow Chart 1.

Water Quality Assessment Procedures

Water Sampling

To start with, the sampling locations were randomly selected. Then, a fair size of representative sample was abstracted. Representative sample refers to a sample in which relative proportions of all pertinent components present as in the universe. The sample volume of 2 liters of drinking water was taken in clean bottles for chemical analysis and 300 mL was taken in sterilized borosilicate bottles for organic analysis with space allowed for aeration. As the source was known to be relatively constant in composition, single grab sampling method was adopted followed by proper labeling and preservation techniques. With above said procedure finally one sample per institution was collected manually. Field measurements of pH and Total Dissolved Solids (TDS) were also carried out.

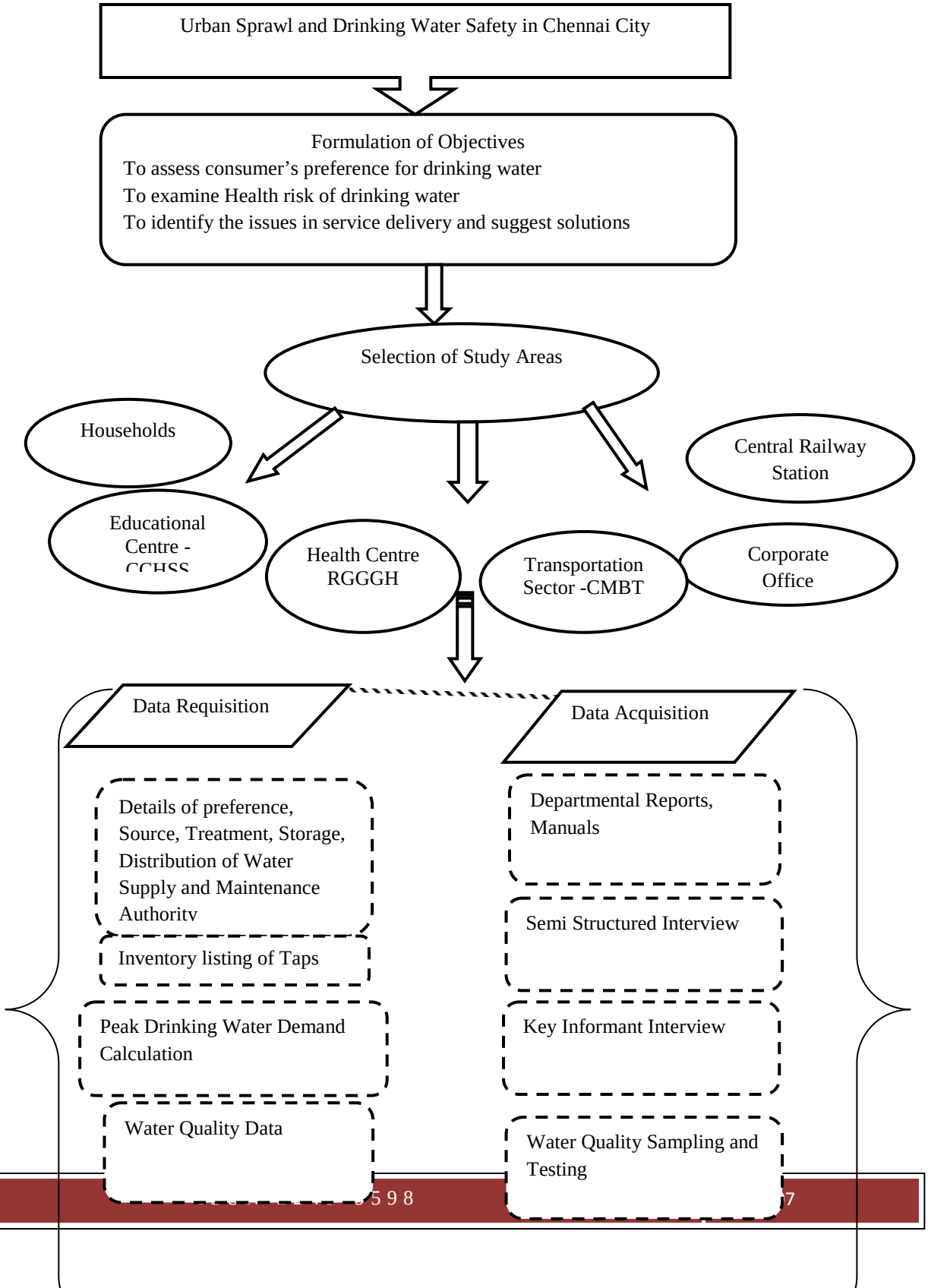
Water Testing

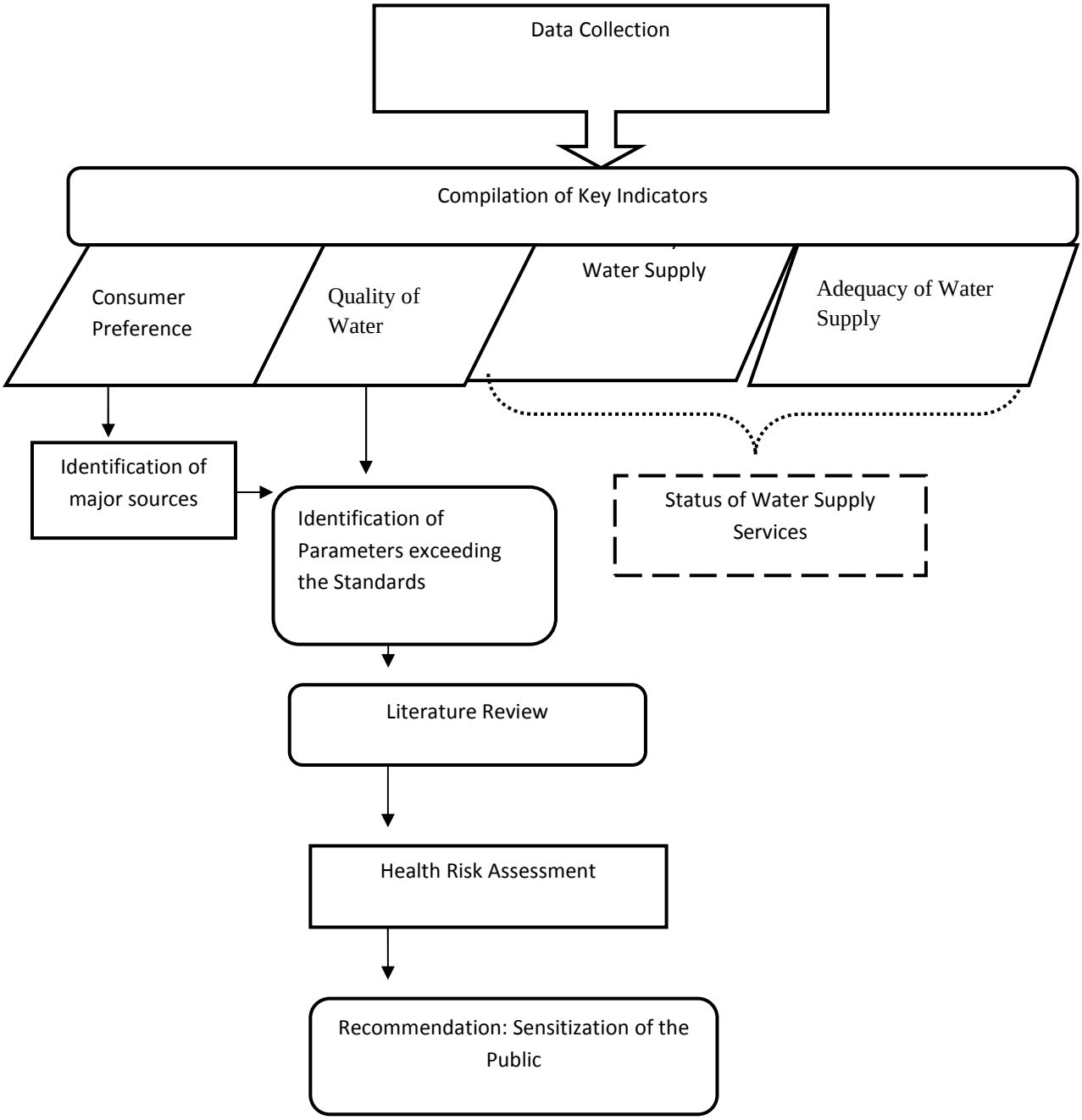
Both physio chemical and biological parameters were tested in the laboratory. For households, a separate analysis was done with reference to Indian Standards of Drinking Water Specification 10500:1991 and for the Institutions procedures provided by CPHEEO manuals were followed. The parameters that were considered are pH, TDS, hardness, alkalinity, iron, manganese, sulphate, nitrate, chloride, fluoride, arsenic, chromium, copper, cyanide, lead, mercury, zinc, total coliform bacteria and fecal coliform bacteria. The biological parameters considered in the study were detected by Most Probable Number Method (MPN) using the multiple tube fermentation techniques**.**

Health Risk Assessment

The parameters which did not meet out the standards along with the range of deviation were identified. From a detailed review of literature on pollution parameters affecting human health risks, risks related to those parameters which exceed the norms were identified and documented as health risks.

Flowchart 1: Frame work of methodology




Data Collection
Compilation of Key Indicators
Consumer Preference
Quality of Water
Water Supply
Adequacy of Water Supply
Identification of major sources
Identification of Parameters exceeding the Standards
Status of Water Supply Services
Literature Review
Health Risk Assessment
Recommendation: Sensitization of the Public

Procedures Adopted for Assessment of Continuity and Adequacy

Continuity of Water Supply

SLB Handbook (2009) defines continuity of supply as the 'average number of hours of pressurized water supply per day'. The term pressurized refers to the water head of 7 meters at the meter point for the connection. In reality this definition could not be used as only few taps were functioning efficiently, while the rest were either fully not functioning or malfunctioning with clogging and leakages. This created difficulty in reckoning the continuity of water supply and therefore, it was decided to employ the method of calculating efficiency of delivering continuous supply as a percentage ratio of the no. of taps functioning continuously to that of total no. of taps under study. The study employed an inventory list of taps as presented in Table.I from which the efficiency representing the continuity of water supply was computed.

Adequacy of Water Supply

SLB Handbook (2009) defines adequacy of water supply based on the per capita water supplied by the distribution system. Many institutional premises are packed with crowd, which normally is floating in nature with variations observed in demand, more in terms of actual number of users, quantity consumed, time and the purpose for which water was used. Therefore, this study considered the peak demand calculation method. This method computes the crowd using the water supply during peak hours and occasions like festivals, weekends, vacations, lunch time and visiting hours. The peak demand calculation sheets containing the visit number, date of visit, reason for the visit along with the quantity consumed are given in Annexures A and C. The selection of tap was randomly done to make this measurement. The demand of households was calculated with the specific two hours of supply daily. The maximum of the observed peak demand is presented in Table .II.

The total amount of water supplied in to the distribution system was obtained as secondary data from the departmental reports as well as primary data collected through key informant interviews. Based on the supply data collected through the above sources, the status of adequacy was determined by comparing with the peak demand. The status of adequacy is discussed below.

Results

Preference

Preference of Households

A detailed semi-structured interview conducted in 1172 households on the preference for using different types of drinking water is presented in figure 3. Among the households, a majority of 600 (51 %) used packaged water, 390 (33%) used supplied water (tap), 172(15%) used both packaged and supplied water and only 10(1%) preferred home purifiers. The study also revealed that the performance of distribution system of Panchayat supplied water in terms of adequacy and continuity was not on par with the requirements of the public. The supply was received once in two days. The response received about the quality of water was mixed and site specific. A few said that the supplied water was fit for drinking while for many it was saline and not fit to drink. This negative response was mainly due to improper

distribution network, leakages and cross contamination due to sewerage and water supply distribution.

In-house Water Filtration System is not used widely; the few systems in use at present purify the water which is pumped from shallow bore wells. The less receptivity of RO filtration is due to its operation and maintenance cost and physical work needed to maintain it The study showed that the installation (home purifier) involved an initial cost of about Rs.13 thousand including the operation and maintenance cost of about 2-3 thousand rupees per year for changing the ceramic filter or for any other failure in the system. From the study it was found that the households felt that home purified water tasted good and there was no health issue in using it when compared to the panchayat (local governing body) supplied water and packaged water. Also it was found that the home purifier was used only by the high income groups who could afford to buy and did not feel it as an economic burden.

Preference in Institutions

The institutions selected for the study were Central Railway Station, School, Bus Terminus, Corporate office and Government General Hospital. The preference of people for drinking water in the institutional environment indicated that the public drinking water supply was preferred as the primary source. Except for corporate office, all other institutions consumed large quantum of tap water supplied through tankers by Metro Water supply Agency to the built-in overhead tanks.

Water Quality Test Results

The water quality test results of the four drinking water samples for various parameters mentioned are given in tables. III and IV.

Health Risk for Households

Water quality tests were carried out with 4 samples (ground water, tap water, packaged water, home purified water) collected from the Kovilambakkam village. The different levels of physical, chemical and biological parameters present in the drinking water were analysed. The pH value of home purified water sample showed the risk of corrosion and metallic taste in water. The source for pH is the geologic formation from which water is extracted. Risks of TDS were hardness, scaly deposits, sediment, cloudy coloured water, staining, salty or bitter taste and corrosion of pipes and fittings. Alkalinity causes deterioration of plumbing and increases the chance of the presence of many heavy metals in water. Total coliform bacteria were found to be present in all the four drinking water samples that include the so called mineral purified packaged water. The effect of total and faecal coliform bacteria in drinking water is gastrointestinal illness. Faecal coliform bacteria were present in bore water and supplied water samples. Diarrhea is often caused by gastrointestinal illness (GI). Usually GI infections cause abdominal cramping followed by diarrhea. The GI illnesses usually cause fever, loss of appetite, Nausea, vomiting, weight loss, dehydration, and mucus or blood in the stool. From the data collected, it was identified that during the rainy season in the year 2011 there has been a number of illness reported, especially jaundice, typhoid, diarrheal diseases and cholera causing hospitalization and even death of a person in the study area.

In the case of packaged water the associated risks both at the supply and consumer end of using plastic wares for storing water are detailed. In general plastics that are marked with recycle codes 3 or 7 are manufactured with BPA (Bisphenol A). Over usage, over washing and exposure to heat causes BPA to leach from the containers. BPA is a weak endocrine disruptor, which can mimic estrogen and may lead to negative health effects. A panel convened by the U.S. National Institutes of Health determined that the children may be more susceptible to BPA exposure than adults. In adults, BPA is eliminated from the body through a detoxification process in the liver, whereas, this pathway is not fully developed in infants and children, so they have a decreased ability to clear BPA from their systems.

Numerous reviews had concluded that obesity may be increased as a function of BPA exposure. People exposed to higher levels of chemical in plastic containers are more likely to develop cardiovascular disease and diabetes. As scientists implicate, cancer, reproductive and cardiovascular system disorders, brain and neurological system dysfunctions, behavioral problems, diabetes and obesity are the risks involved in over usage of plastic, galvanizing political and regulatory efforts to rein in environmental pollutants. The mounting non degradable plastic waste also affects the environment by and large. More than 90 percent of the sampled users of public utilities were using plastic can / pots for collecting and storing water.

Quality of water Supply in the Institutional Environment

The test results of samples of CMBT, Central, Corporate office, RGGGH and CCHSS labeled as B,R,H,C and S respectively are listed in the table V. The table shows the presence of faecal coliforms in school sample and the presence of Iron in various institutions. From the water quality data of each institution, it was observed that faecal coliform and iron exceed the standards and acted as risk factors in institutions such as schools. Following segment illustrates the probable risks associated with these factors in addition to those caused due to consumer behaviours.

Health Risk in the Institutional environment

P.S Mead et al, (2011) states that.Escherichia Coli 0157:H7 faecal coliforms often causes severe, acute hemorrhagic diarrhea and abdominal cramps. It can also be asymptomatic. In some people, particularly children under five years of age and the elderly, the infection can cause hemolytic uremic syndrome (HUS), in which the red blood cells are destroyed and the kidney fails. About 2-7% of infections lead to this complication. They also cause the most important gastrointestinal diseases such as cholera, salmonellosis and shigellosis. It is declared that iron is not known to be hazardous to health. It is considered as a secondary or as an aesthetic contaminant except for Hematochromatosis, an inherited disease that affects 5 out of 1,000 people in persons having too much iron in blood. While people normally absorb around 10 percent of the iron, people with too much iron in blood absorb up to 30 percent; hence, only people with this disease need to avoid taking in excess iron, including iron in water. Hydrogen sulphide gas, a frequent derivative of iron bacteria, gives water a distinct rotten egg odour as well as adding reddish-brown colour to the water. It gives a metallic taste to the drinking water. It increases organic content in water favouring the multiplication of other bacteria such as sulphur bacteria causing bad taste, odour and appearance. Indira and Romit (2008) suggest that one has to improve the ways in which we collect and store water so as to avoid contamination while

collection, storage and use. Consumers who are unaware of personal hygiene and cleanliness suffer from risks due to cross contamination. This transmission mostly occurs when consumers draw water without washing hands or the containers. Due to the transmission of harmful microbes present either in the hands or vessels, the consumers are at risk of vomiting, diarrhea, skin rashes, stomach pains, nausea, dizziness and even chronic health effects that include cancer, liver and kidney damage, disorders of the nervous system, damage to the immune system, and birth defects. Chronic health effects occur during heavy exposure to the risks factors. Attempts were made to quantify these effects through data collection from authentic sources. But it was unsuccessful due to procedural implications.

Status of Drinking Water Supply

To summarise, although there was adequate quantum of water for supply, one hundred percent continuous supply was not ensured in any institution except in Corporate Office, which created non availability of adequate water during the time of requirement which was also termed as Pseudo-inadequacy. In addition to pseudo-inadequacy in Corporate office, the presence of coliforms in school sample made clear of the existing poor service delivery.

Determination of Continuity of Water Supply

As mentioned in the methodology, continuity is obtained in terms of efficiency of the functioning taps that are capable of supplying continuous water supply. The following table VI and figure.4 represent the efficiency of each institution in delivering continuous water supply.

In central railway station, despite the truth, that the numbers of taps present in the railway station is higher, the status of continuity is very low, to say less than 50%, due to the failure of taps located in the drinking water hubs sited at platforms. In the case of school it is found only on an average 60% of taps functioning. The young children are vulnerable to diseases and susceptible to its serious consequences because their immune systems are experiencing everything for the first time and it is estimated that 443 million school days are lost each year due to water-related diseases (Facts and Statistics, 2011).

The primary objective of hospitals is to provide comprehensive health care services to the patients. The facilities to provide continuous water supply to the hospital patients and people visiting the hospital are not meeting their requirements.. The continuity is only about 60% the short supply of water in turn would affect the sanitation and health of the hospital environment which has both direct and indirect effect on the patients.

From the adequacy point of view shown in Table VII and figure. 5, the water supplied is however able to meet the requirement while its distribution and the infrastructure used are seudo adequate; in other words water supply is either not enough at times of need.or not monitored properly for effective and efficient delivery at the time of requirement.

Discussions

From the study, it was found out that the packaged water was preferred by the people in the households, as in their perception it was tastier and healthier than the other sources of drinking water. At the community level from the results of the water quality test over the drinking water sources and surface water source it was found that these sources were contaminated with bacteria. The risk factors on health in consuming the water contaminated with harmful bacteria were studied keeping the Bureau of Indian Standards for Drinking Water as bench mark.

The risks identified were listed and the fatalities of the risks were explained through various PRA tools. Sensitisation was done by creating awareness in the community about needs, desirable improvements, monitoring and maintenance of the water sources.

In the institutional environment, the preference was much more for the supplied water than the other sources for the reason that people perceived it to be cost effective, easily accessible and portable. The study revealed the current status of inadequate distribution of water supply services provided in the institutional premises. The findings exhibited a state of false adequacy; adequate water was available but reliable and safe supplies were questions due to lack of maintenance and infrastructure. With respect to the quality, despite the samples meeting the norms of CPHEEO, there were also samples with the presence of faecal coliforms in specific it was found in school sample. The consequence of drinking the water would result in the risks of diarrhea, nausea, stomach ulcers and abdominal cramps and in case of heavy exposure to kidney failures and nervous disorders. Besides the risks evolving from supply end, lack of personal hygiene and awareness also plays vital roles in determining the health of the people.

One area which has not been given due attention as far as drinking water supply of Chennai city is the collection of rain water through innumerable community tanks existing within urban and peri urban areas. Safe and cost effective water which had been a dream for Chennai urban poor could come true through rehabilitation of community tanks and the use of bio-sand filters. Awareness creation through PRA tools has added crown to the study as it served instrumental in minimizing the health risk, reduce school drop outs, absenteeism to school and work place which proved to have affected our national economy.

References

Arghyam, Bureau of Indian Standards for Drinking Water IS 10500. (1991). Ministry of Water Resources, Government of India. Available on-line at: http://www.mowr.gov.in.

Welcome to Kanchipuram Website. (2004). District Administration Kancheepuram District Profile. Available on-line at: http://www kanchi.nic.in/district_profile _pro.html.

Dutta V. Ashutosh Singh et al. (2010). Urban Sprawl and Water Stress with respect to Changing \ Landscape: Study from Lucknow, India Journal of Geography and

Regional Planning, l.2 (5): p.84-105. Available online at: http://www.academicjournals.org/JGRP.

Environmental Health Fact Sheet. (2012). Coliform Bacteria and Drinking Water. Available on-line at http:www//ewashtenaw.org/government/ departments/ environmental_health/wells_septic/well_septic_pdf/eh_coliformfactsheet.pdf .

Jones Q. A, Catherine E Dewey**,** et al. (2006). Public perceptions of drinking water: a postal survey of residents with private water supplies. BMC Public Health Pp.6:94. Available on-line at http://www.biomedcentral.com/1471-2458/6/94

Kovilambakkam to Pallikaranai. (2007). Holy India.org. Available online-at http://www.holyindia.org/map/kovilambakkam_to_pallikaranai/bus

Krishnakumar, A. (2001). Water Supply Chennai's Agony. Frontline, India's National Magazine from the Publishers of The Hindu. Available on-line at http://www.frontline.in/static/html/fl1813/18130900.htm

Khurana i. and Romit Sen, Wateraid. The Human Right to Water, 19:66 pp 12.

Lakshmi K. (2011). Demand for Water Goes up. the Hindu News Paper, Available on-line at :http://www.thehindu.com/news/cities/chennai/article1702279.

Loganathan D, S. Kamachiammal. (2011). Status of groundwater at Chennai city, India. Indian Journal of Science and Technology, Indian Society for Education and Environment. 4(5):Pp. 566-572. Available on-line at www.researchgate.net/...groundwater.../e0b49519db35280331.pdf.

Lorna A, Ward. (2009). Health Beliefs about Bottled Water. A Qualitative Study. BMC Public Health, 9 Pp 196. Available on-line at http://www.biomed central.com/1471-2458/9/196

Manjula S, Rajendran. P et al. (1993). Assessment of Bacteriological Quality of Potable Water from Madras City Indian journal of Medical Microbiology Medknow publications 11(4) Pp 234-237.

McKenzie D, Isha Ray. Year Anonymous. Urban Water Supply in India: Status, Reform Options and Possible Lessons, Urban Water India Final version forthcoming in Water Policy available online at http://erg.berkeley.edu/Publications/Isha%20Ray/McKenzieRay-India-urbanwater-forWP.pdf.

Mead P.S. and Mary A. Lambert-Fair et al, (1997). Risk Factors for Sporadic Infection With Escherichia coli 0157:H7. Available on-line at http://archinte.jamanetwork.com/article.aspx?articleid=622767

Mohan S. (2010). Issues in Water Governance, Service Delivery in Mumbai and Chennai Volume: 1(I), e- Journal of History and Social Sciences. Available on line at http://jhss.org/articleview.php?artid=20.

Rajan, S. (2012). A study of drinking water quality of Amjikarai, J.J. Nagar, Valluvar Kottam and Vadapalani area of Chennai, Tamil Nadu. Web Med Central Available on-line at http://www.webmedcentral.com/article_view/3655.

Tu J, et al., (2007), 'Impact of urban sprawl on water quality in eastern Massachusetts,' USA**.** Department of Environmental, Geographic and Geological Sciences, Lehman College, The City University of New York, 250 Bedford Park Blvd. West, Bronx, NY 10468, USA.

.