Journal of Global Resources Volume 5 (01) January 2019 Page 33-42
ISSN: 2395-3160 (Print), 2455-2445 (Online)

04

A GIS BASED APPROACH FOR DRINKING WATER MANAGEMENT IN URBAN SLUMS

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Abstract: *The present paper involves detailed study of the selected slums in Greater Mumbai for evaluating drinking water issues and challenges in slums. Safe and adequate drinking water is a basic human need. Detailed investigation of slums has been conducted along with the officials of Municipal Corporation of Greater Mumbai (MCGM). For detailed investigation, the slums were selected based on the ward size, slum population in the ward, information from the secondary sources and laboratory investigation of drinking water samples collected from slums. Participation of local slum dwellers was ensured in the study to understand the drinking water problems and issues at grass root level. Samples collected from household storage containers have shown an increase in contamination as compared to the samples collected from tap water. E. coli contamination was found in few samples. Mosquito larvae was found along with coliform contamination in the stored water collected from households. An observational study was done with each of the field visits to assess water handling and hygiene. GIS database will be generated which will bring complete understanding of drinking water issues in slums. GIS will store, analyse and display spatial data which can be useful for long term planning for drinking water management.*

Key words: *Geographical Information System (GIS), Water Management, Slums and Drinking Water Quality.*

Introduction

Water is essential to sustain life and an adequate supply of safe drinking water is a basic human need. As per the Sustainable Development Goal (SDG) there should be universal and equitable access to safe and affordable drinking water for all by 2030. It is important to support and strengthen the participation of local communities in improving water and sanitation management (Open working group proposal for the Sustainable Development Goals, 2014). According to the progress report of UN SDG 2016, significant progress has been made in access to drinking water. In 2015, 6.6 billion people i.e. 91 percent of the global population used an improved drinking water source, versus 82 percent in 2000. Despite that improvement, an estimated 663 million people were using unimproved water sources or surface water that year. While coverage was around 90 per cent or more in all regions except sub-Saharan Africa and Oceania, widespread inequalities persist within and among countries. Moreover, not all improved sources are safe. Microbial contamination is responsible for the great majority of water-related health burden. WHO recommends that the microbial quality of drinking-water be measured using faecal indicator bacteria, preferably *Escherichia coli*; these bacteria are chosen to indicate the presence of faecal contamination rather than identifying pathogens directly (WHO 2008, Bain et al, 2012). It is estimated that 15–20 percent of community diarrhoeal disease in developing countries is attributable to unsafe drinking water with recent studies indicating even higher percentages of waterborne diarrhoeal disease. Waterborne infectious diseases are caused by a variety of

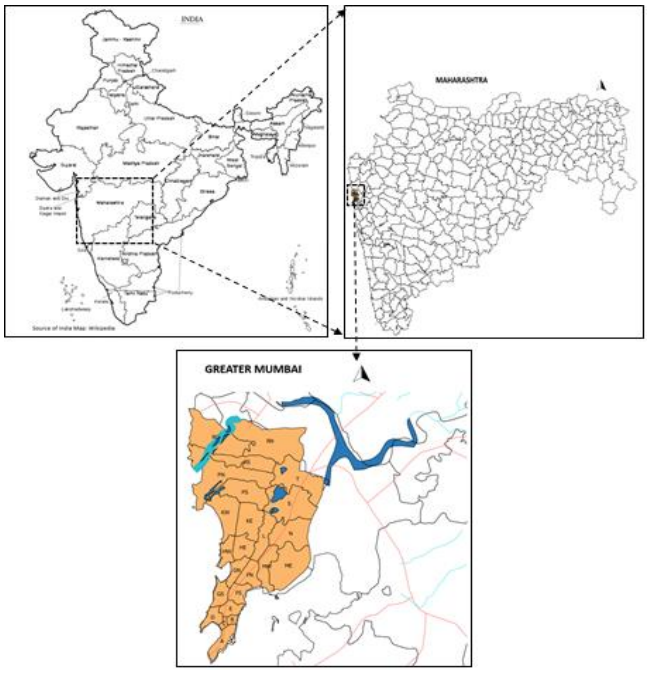
microbial agents (pathogens) that contaminate drinking water supplies in developed and developing countries (Quick et al., 1999; Sobsey et al., 2003). It is estimated that about 37.7 million Indians are affected by waterborne diseases, 1.5 million children die of diarrhoea and 73 million working days are lost due to waterborne diseases annually. Further 10.28 per cent of all habitations are affected by poor water quality (Water Aid India, 2017, Pathak H. 2015).

Equitable access to safe and affordable drinking water is a major challenge in urban slums. In 2002, the UN operationally defined slums as those communities characterized by: insecure residential status, poor structural quality of housing, overcrowding, and inadequate access to safe water, sanitation, and other infrastructure (UN-Habitat, 2002; Unger A., Riley L.W., 2007). People living in slums are the worst victims of poor quality of water, by inadequacies of drainage, sanitation and household waste removal facilities and, in general, by unhealthy living and working environments (Swaminathan, 1995; Hardoy, J.E. and D. Satterthwaite, 1989). The present study is therefore undertaken to address drinking water issues in slums. Storage of water and keeping it safe from contamination is a major challenge for slum dwellers. Therefore, in this study along with tap water (individual taps and common collection point), drinking water samples were also collected from stored container and water quality was tested for physical, chemical and microbial contamination. Based on the results of laboratory investigation, slum population in the ward and information from secondary sources slums were selected for detailed investigation.

Study Area

The study area in the present work has been selected as Greater Mumbai because approximately half of the population of Greater Mumbai lives in slums. The current population of Greater Mumbai as per 2011 census is 12.44 million inhabitants, among which approximately 42 percent are living in slums. Greater Mumbai is located on the western most periphery of the Maharashtra State. The Mumbai city is known as financial capital of India. Greater Mumbai is located at North latitude from 18°53’ to 19°19’ and East Longitude from 72°47’ to 72°59’ (Gupta S. Greater Mumbai District, Maharashtra, Ground Water Information, Govt. of India, Ministry of Water Resources, CGWB, 2013). Location map of the study area has been prepared using GIS and is shown in Figure 1.

Figure 1: Location Map

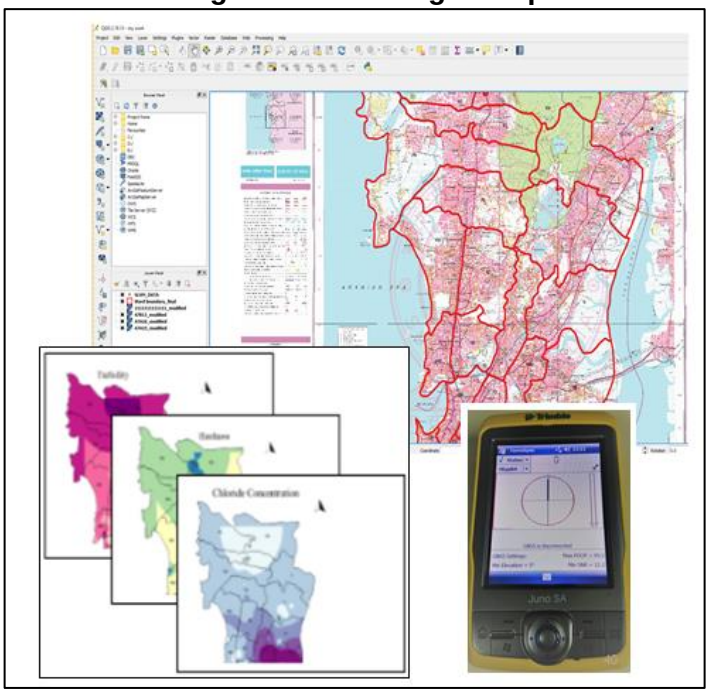


The water supply for Mumbai is sourced from 7 different lakes such as Upper Vaitarna, Modak Sagar, Tansa, Middle Vaitarna, Bhatsa, Vehar, Tulsi and is treated at 4-Water Treatment Plants as per drinking water standards specified in IS 10500: 2012 before being distributed to the citizens (Municipal Corporation of Greater Mumbai). Mumbai, the capital of economic development in India, has been under pressure due to industrial, commercial, and population growth (Kamble et al., 2011). With the rapid urbanization, the city dwellers not only add to population but also pollution. These urban poor are also understood to be the biggest sufferer group of urban society and major victims of all types of environmental pollution and other epidemics due to their living in pathogen-prone neighbourhoods, with cramped conditions in shacks and limited access to basic civic services like safe and adequate water supply, sewerage and drainage, sanitary toilets, solid waste disposal facilities (Hardoy et al., 1997, Karn et al., 2002). In the present study, detailed investigation of slums has been conducted to evaluate drinking water issues and challenges faced by slum dwellers and database has been generated using GIS.

Detailed investigation of drinking water issues in slums in Greater Mumbai

Advance technique comprising Geographical Information System (GIS) and Global Positioning System (GPS) has been used in this study to arrive at most effective methodology for sustainable drinking water management for urban slums. GIS database will bring complete understanding of drinking water issues in slums. Slums and sample points were located using GPS. Figure 2 shows database generation in GIS framework.

Figure 2: Database generation using Geospatial Technology



To achieve universal and equitable access to safe and affordable drinking water for all, the best indicator is the proportion of population using safely managed drinking water services. Therefore, ward wise population map was generated using QGIS as shown in Figure 3. However, objective of the study is to address drinking water issues in slums. Therefore, mapping of percentage of slum population in each ward was done using GIS. Figure 4 shows the map of percentage of slum population to the total ward population. It can be clearly seen that in few wards, slum population is more than 50 percent (White Paper, Report on The State of Affordable Housing

in Mumbai, November 2014 PRAJA.ORG; Census of India 2011, District Census Handbook, Mumbai).

Figure 3: Population map of Greater Mumbai

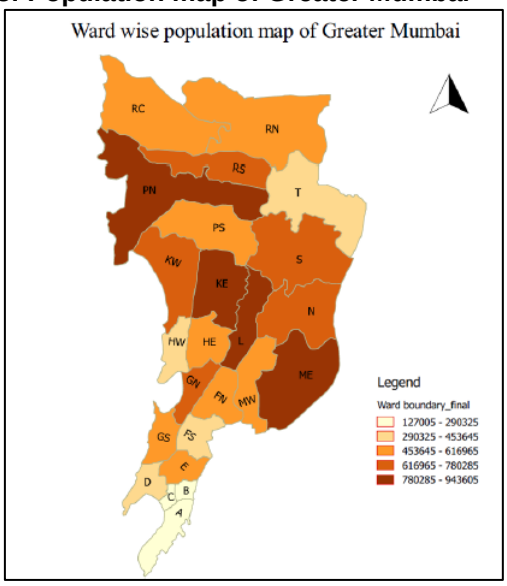
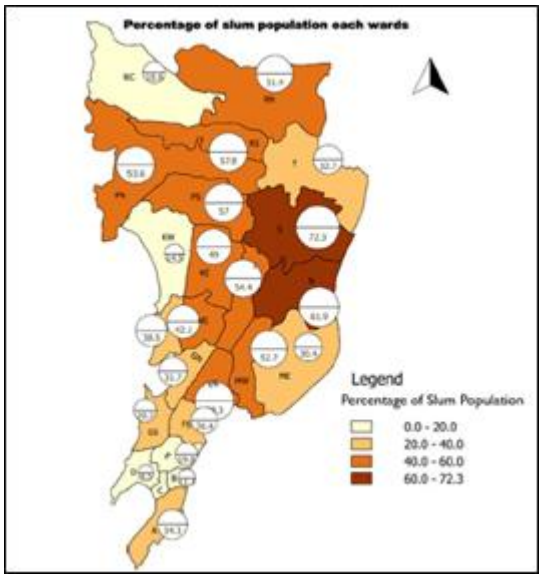


Figure 4: Percentage of slum population in each ward



Detailed study of two slums as shown in Figure 5 (one in Mankhurd region and the other in Kannamwar Nagar in Greater Mumbai) has been conducted along with the officials of Municipal Corporation of Greater Mumbai (MCGM). Slums were selected based on the ward size, slum population in the ward, information from the secondary source and laboratory investigation of drinking water samples collected from slums.

Figure 5: (a) Location of slums (b) Project team and MCGM Official for detailed investigation

(a) (b)

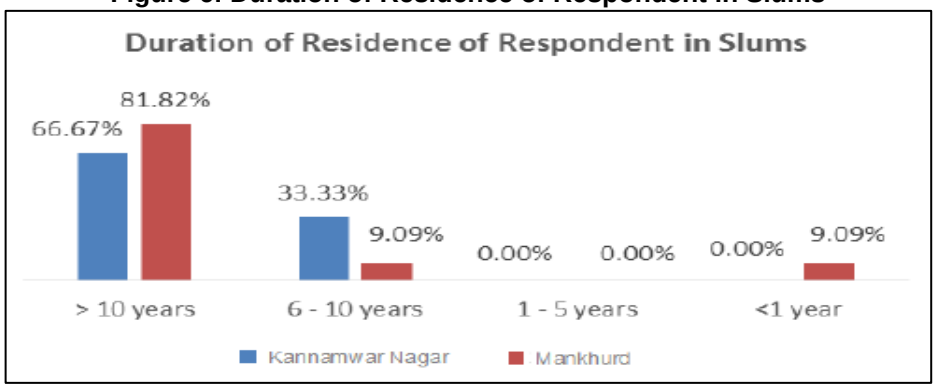
Questionnaire was prepared for detailed investigation which included questions on the source of drinking water, distance from water collection point, access to piped water, availability of drinking water in a day, average time for water collection, monthly expense incurred for drinking water availability and it purification, quality of water, storage of water, water purification methods at household level, etc. Participation of local slum dwellers was ensured in the study to understand

the drinking water problems and issues at grass root level. Based on the analysis of the questionnaires filled by the respondents, various aspects of drinking water management scenario in Mumbai slums were studied. The questionnaire captured the views, concerns, problems, expectations of the slum residents. The aspects of quality, quantity and frequency of drinking water supplied to slums were studied in detail. Additionally, the existing systems in place for supply of drinking water were studied. Further, a comparison of the two slums was done to understand the similarity and differences across these slums. Based on the detailed analysis, trends were established and results were derived to understand the scenario of drinking water management of slums in Mumbai. Water samples which were collected from storage containers have shown bacterial contamination. Mosquito larvae was found in some of the stored water samples.

Analysis

Almost all respondents of both the slums were residing in the respective slums for more than 6 years as seen in Figure 6. Of the respondents of Kannamwar Nagar slum, over 66.67 percent respondents were residing in the slums for more than 10 years while 81.82 percent of the respondents of Mankhurd slum were residing for more than 10 years. This indicates that the respondents are aware of the conditions of slums.

Figure 6: Duration of Residence of Respondent in Slums



The most common source of drinking water at Mankhurd slum is individual tap while in Kannamwar Nagar slum is common stand pipe i.e. public tap (Figure 7). About 4.55 percent of respondents use tubewell as a drinking water source in Mankhurd slum while none use tubewell in Kannamwar Nagar. None of the respondents across use open wells, river, water tanker or rain water storage as a drinking water source.

Figure 7: Source of Drinking Water

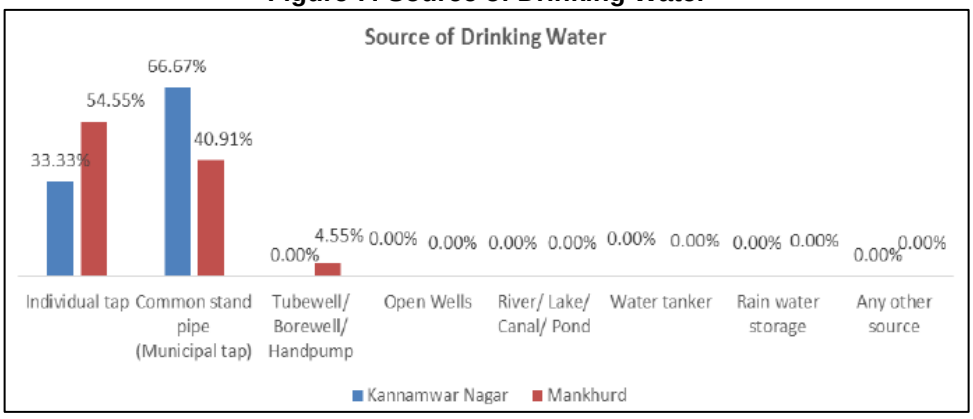
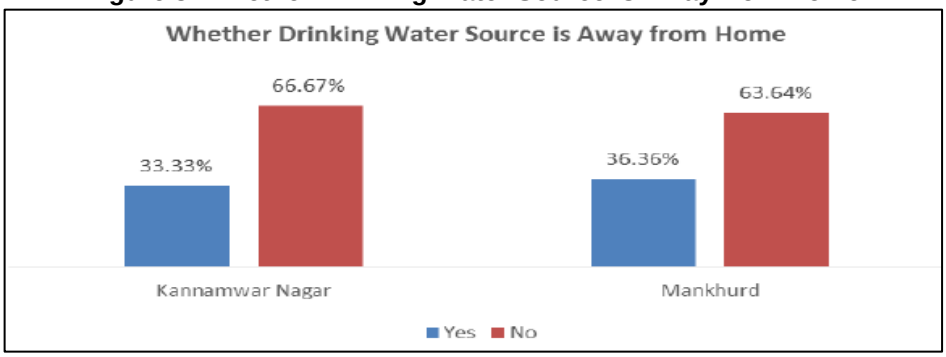


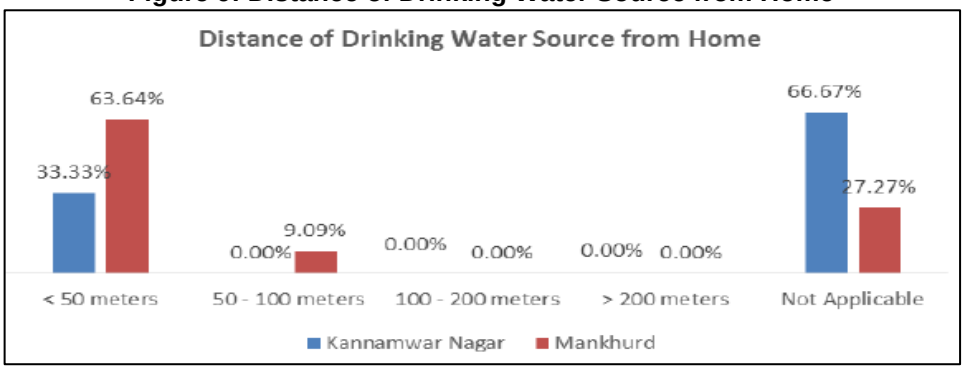
Figure 8 represents that about 33.33 percent of residents of Kannamwar Nagar have their homes away from drinking water source while 36.36 percent residents of Mankhurd slum have their homes away from drinking water source.

Figure 8: Whether Drinking Water Source is Away from Home



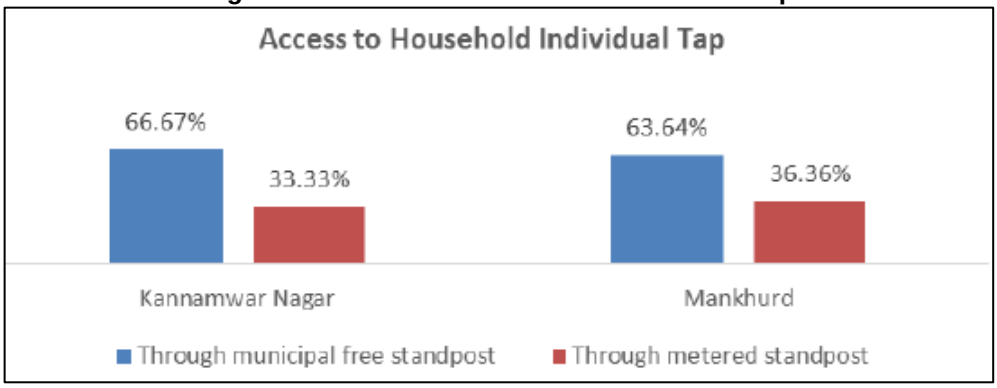
More than 60 percent of the residents of Mankhurd slum have their homes at a distance of less than 50 metres from drinking water source. Figure 9 and Figure 10 collectively indicate that slum residents of Mumbai do not have to travel far distances to collect drinking water from source as it is close to their houses.

Figure 9: Distance of Drinking Water Source from Home



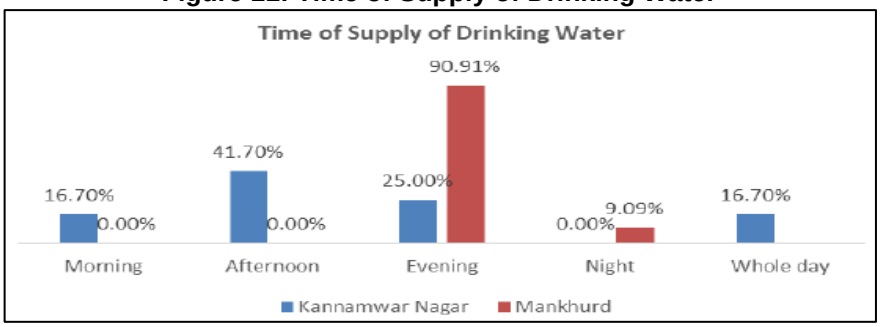
Over 66.67 percent respondents in Kannamwar Nagar slum and 63.64 percent in Mankhurd slum have access to household individual tap through municipal free standpost. Less than 40 percent of respondents in both slums have access through metered stand post. This indicates that slums of Mumbai rely more on municipal supply.

Figure 10: Access to Household Individual Tap



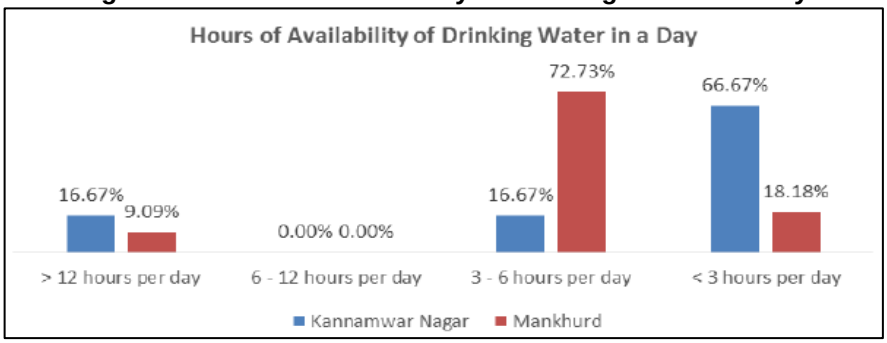
As seen in Figure 11, in Kannamwar Nagar slum, there were different timings of water supply observed as residents responded with varied timings. Half of the respondents said that the time of supply is around 2:00 pm. In Mankhurd slum, more than 90 percent respondents said that the time of supply of drinking water is in the evening at around 6 pm.

Figure 11: Time of Supply of Drinking Water



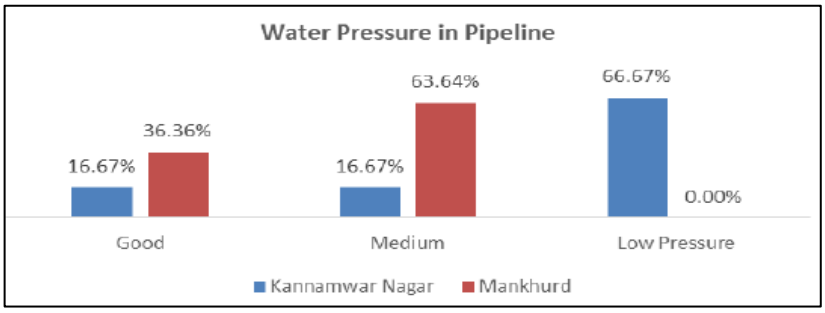
As indicated in Figure 12, more than 65 percent respondents of Kannamwar Nagar slum said that water is supplied for less than 3 hours a day. More than 70 percent respondents of Mankhurd slum said that water is supplied for 3 to 6 hours in a day. Thus, it can be concluded that the time of availability of drinking water is more in Mankhurd slum. Additionally, the average time for water collection in a day including waiting time for slum residents of Kannamwar Nagar slum is about 2 hours while for slum residents of Mankhurd slum is about an hour. The respondents said that one person from the family collects drinking water from the source every day.

Figure 12: Hours of Availability of Drinking Water in a Day



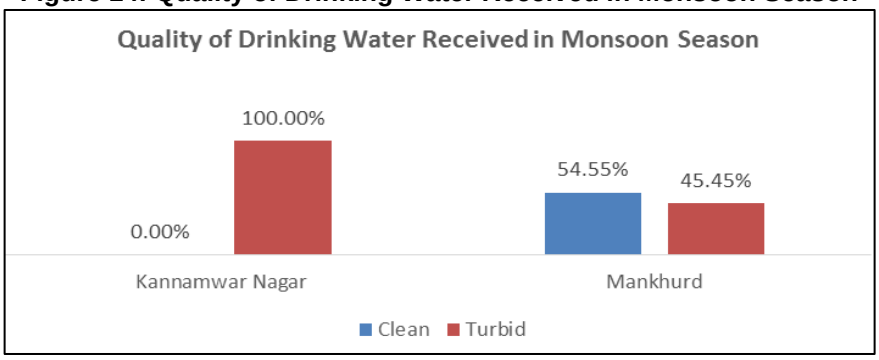
As seen in Figure 13, none of the respondents of Mankhurd slum said that water pressure in pipeline is low. All respondents said that the water pressure is either medium or good. Contrary to this, 66.67 percent respondents of Kannamwar Nagar slum responded that the pressure in pipeline of Kannamwar Nagar slum is low. Thus, it can be said that pressure in pipeline is a problem in Kannamwar Nagar slum.

Figure13: Water Pressure in Pipeline



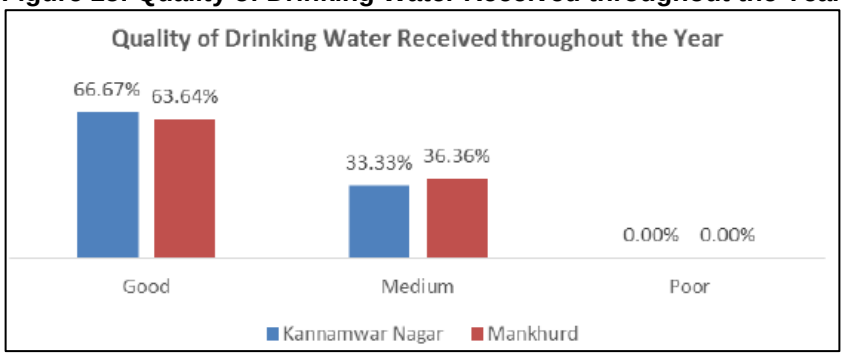
According to respondents, during monsoon season, the water is turbid (Figure 14). Water quality is deteriorated significantly. In Kannamwar Nagar slum, all respondents said that water received is turbid. Over 40 percent respondents of both slums said that certain diseases such as viral fever, cough, diarrhoea, jaundice, typhoid, etc. are prevalent in the slums due to the poor quality of drinking water especially during monsoons.

Figure 14: Quality of Drinking Water Received in Monsoon Season



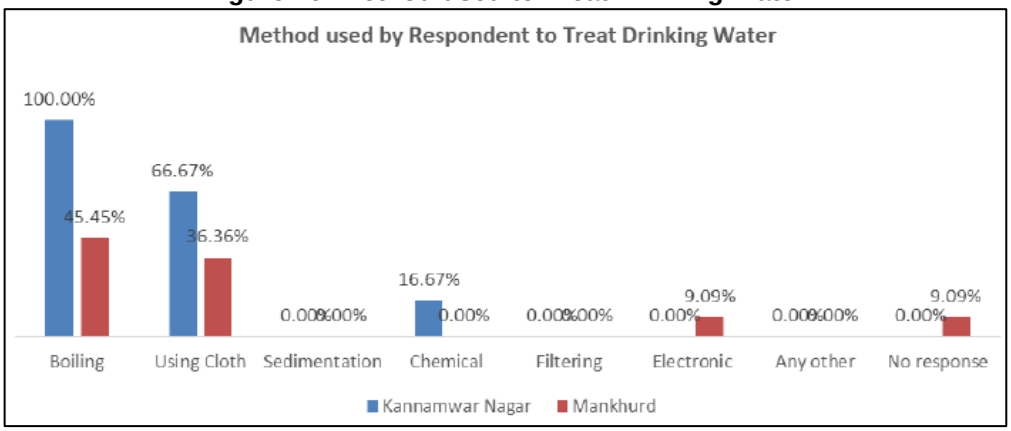
However, the quality of drinking water received in both slums throughout the year except in monsoon season is satisfactory (Figure 15).

Figure 15: Quality of Drinking Water Received throughout the Year



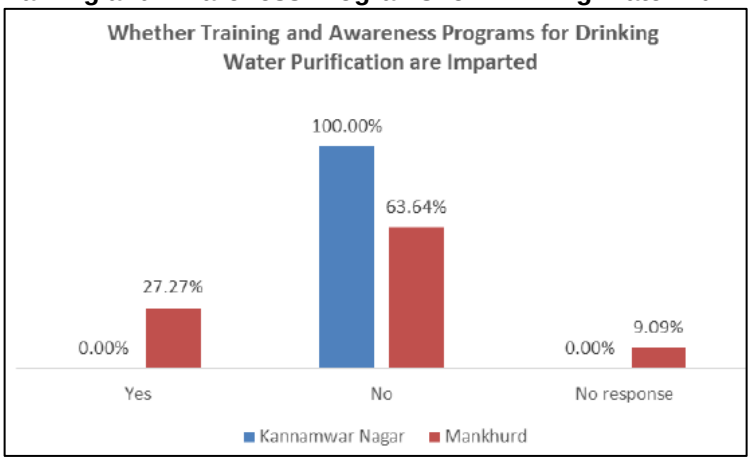
Various methods used by slum residents to purify drinking water at household level is shown in Figure 16. In Kannamwar Nagar slum, all respondents use the method of boiling while in Mankhurd slum, 45.45 percent respondents use the method of boiling to treat drinking water.A fair number of respondents in both slums use cloth to treat drinking water. None of the respondents in Kannamwar Nagar slum use sedimentation, filtering or electronic medium, to treat drinking water.

Figure 16: Method used to Treat Drinking Water



As observed in Figure 17, none of the respondents said that adequate training is being provided while 27.27 percent respondents in Mankhurd slum said that training and awareness programs for drinking water purification are imparted either by municipal body or private agencies. The same is required for creating awareness of its importance. This indicates that training and sensitization is required for local people on the storage of drinking water and low-cost drinking water purification methods.

Figure 17: Need of Training and Awareness Programs for Drinking Water Purification are Imparted



Conclusion

Based upon the analysis, major problems of the region and salient finding emerged from the study are lack of awareness of local slum people on proper storage of drinking water and use of household purification methods. Most of the coliform contamination have resulted from the poor storage of drinking water. Certain samples showed bacterial contamination due to rain water logging and mixing with the drinking water pipelines due to two reasons observed: (a) the pipelines outside the slums have not been maintained well (b) the low-lying areas are prone to flooding in monsoon. Possible measure to overcome such problem is sensitization of local people and knowledge dissemination by involving Government stakeholders on the storage of drinking water and low-cost drinking water purification methods. In both the slums surveyed, water supply was found to be intermittent. The average duration of water supply was found to be 3 hrs, per day. As a result, local people store water in large containers which becomes difficult for them to keep it safe from contamination. This leads to poor hygiene. Bacterial contamination was found in such stored samples in few of the water samples collected from slums. A major concern for Kannamwar Nagar slum is the low pressure of pipeline.

However, a major concern for Mankhurd slum is the quality of water supplied during monsoon season. Leakages in the pipeline were also observed as the pipelines were too old. Condition of household storage container was not found to be good. Clothes were used as water filter and dirty clothes causes contamination. Water samples which were collected from storage containers have shown bacterial contamination. Mosquito larvae was found in the stored water samples. An initiative has been taken to generate GIS database which will bring complete understanding of drinking water issues in slums. GIS is a tool which can store, analyse and display spatial datawhich can be useful for long term planning for drinking water management.During detailed investigation of slums, it was observed that different slums were having different problems of drinking water. In some of the slums, there was a major problem of leakage. However, in other slums the problem was of low pressure. Therefore, GIS database will help in providing location specific long-term solutions for drinking water problem.

Acknowledgement
Authors are thankful to NRDMS Division of Department of Science & Technology (DST), Govt. of India for sanctioning and funding the project. We are also thankful to Municipal Corporation of Greater Mumbai (MCGM) for guiding and supporting us in the study.

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