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RESEARCH ARTICLE

STUDY OF TANKER WATER IN MUMBAI FOR ITS ROLE IN SPREADING WATERBORNE DISEASES AND OTHER HEALTH HAZARDS RELATED TO DISSOLVED CHEMICALS

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ABSTRACT

Microbiological and chemical quality of drinking water primarily results from water origin and type of applied water treatment. Since the drinking water is one of the main way through which many infectious agents can be transmitted to humans causing waterborne diseases, constant monitoring of drinking water quality in water supply systems is needed. This study investigates the microbiological quality of tanker water supplied in different localities in Mumbai during summer, Rainy and winter season for the period of the year July 2011 - April 2012. Since increased concentrations of some chemical compounds in water can influence on appearance and growth of microbiological populations, in this study relevant physicochemical parameters were also measured and correlated with obtained values of analysed microbiological parameters. Physico-chemical parameters studied includes determination of the pH, temperature, turbidity, hardness, alkalinity, chlorides, fluorides nitrate, iron, silica levels in the water samples. The results obtained indicated that the chemical quality of the water samples under study falls within the standards recommended by World Health Organisation. However, more potentially dangerous discovery was the level of Coliform contamination which exceeds the WHO standards. Other microorganisms detected were *E. coli, Enterobacter*, *Salmonella, Pseudomonas*. This can result in the high incidence of water-borne diseases such as Dysentry, Diarrhea and Typhoid fever.

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INTRODUCTION

Rapid urbanisation is making it more and more difficult for governments to provide adequate piped water services, particularly in urban areas. In the absence of piped water systems, communities in these areas meet their water needs through various means. They either access water freely from public or private sources or purchase water from different sources. Tankers or water trucks provide water to hotels, schools, private bungalows, building contractors and also to water vendors. They also store water in tanks and sell water in jerry cans (Cretikos *et al.,* 2010). There is no regulation or monitoring of the quality of water supplied by these private suppliers. Since the water in these tankers had been extracted from bore wells or open wells in agricultural areas, the potential for microbial growth due to faecal contamination is always present. Also, within the tanker, water may become contaminated due to prolonged containment stimulating biological growth or through poor sanitation practices. Such contaminated water can transmit diseases and can lead to serious health hazards (Asbolt 2004; Catling *et al.,* 2008). Water quality is classified using many parameters like physical, chemical, biological. Physical parameters include colour, odour, turbidity, and temperature. Chemical parameters are divided into two general categories: organic and inorganic compounds. Inorganic chemicals include many elements such as arsenic, lead, nitrate, sodium, calcium, and oxygen. Organic chemicals include various hydrocarbons, sulphur compounds, and oxygen derivatives and come from pollutants such as pesticides and detergents. Some chemicals found in water have sudden health impacts if they are present in large concentrations. While chemicals pose some health problems, bacteria and viruses, both biological parameters, are of the most concern because it is these organisms which often have immediate effects on the human body. Microbiological parameters are also indicators of potential waterborne diseases. Physical and chemical parameters are directly related to micro-organisms and productivity of water bodies. Presence of nutrients, in water like nitrate and organo-phosphate help in growth and development of microbes (Soni *et al.,* 2013; Verma *et al.,* 2012). *E. coli* is a bacterium that colonizes the gastrointestinal tract of humans and other mammals and is considered part of our normal intestinal flora. Some types of *E. coli*, such as *E. coli O157:H7* can cause diarrheal disease in humans. Due to its high prevalence and disease-causing properties, it is used as an indicator organism. As per the WHO

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guidelines Coliform bacteria like *E.coli* "Must not be detectable in any 100 ml sample" of water intended for drinking. The water supplied by tankers possess a high risk of transmitting *E.coli* due to unhygienic practices (Kataria and Ambhore 2012). Keeping in view the aforesaid facts, the present study was taken up to analyze physicochemical and biological parameters of tanker water samples collected from the selective localities of Mumbai and to assess health impacts linked with the consumption of unsafe drinking water

MATERIALS AND METHODS

Sampling

In order to assess the quality of tanker water in Mumbai, representative localities were selected. 200 ml of tanker water samples were collected randomly from selected localities in clean plastic bottles and taken to the laboratory. The water quality is also subject to seasonal variation. In order to study the seasonal variations, a total of 25 water samples were collected during each season (summer, rainy, winter season).

Laboratory Analysis

The laboratory analysis of samples was done immediately within 6 hours using standard methods (APHA 1998).Temperature and pH were recorded by using digital thermometer and pH strips respectively. Digital TDS meter was used to determine the total dissolved solids (TDS) content of the sample while other parameters such as turbidity, hardness, alkalinity, chlorides, fluorides, nitrate, iron, silica were estimated in the laboratory by using HI-Media test kits (HiMedia Test Kit- K015, Water Test Kit- WT015, Alkalinity Test Kit- WT003A, Silica Test Kit- WT009). For the bacteriological analysis of water, McConkey broth was used for the MPN count of coliforms. Nutrient agar, Eosin – Methylene blue agar, Salmonella –Shigella agar, Thiosulphate –Citrate Bile Sucrose agar and Xylose Lysine Decarboxylase agarwere used for the isolation and differentiation of micro-organisms from the positive MPN tubes (Figueras and Borrego 2010; Grant and Zeil, 1996).The bacterial isolates were further identified using morphological, cultural and biochemical tests with reference to Bergey's Manual of Determinative Bacteriology (Omezuruike *et al.,* 2008).

RESULTS AND DISCUSSION

Physico-Chemical analysis

The mean values of the physico-chemical properties of the tanker water samples collected during different seasons are shown in Table 1. The water temperature is an important factor which influences the biochemical characteristics of water body. In present study the temperature varied from 26^0C - 30^0C in all the seasons. The mean temperature recorded during summer was higher than in rainy and winter season. This variation in the water temperature may be due to different timing of collection and influence of season (Thivya *et al.,* 2014). As far as pH is concerned, many biological activities can occur only within a narrow range. Thus, any variation beyond an acceptable range could be fatal to a particular organism (Napacho and Manyele 2010). In present study pH was reported to be neutral for all the samples, values ranges from 6.5 to 7.0, hence falls within recommended limits (6.0-8.0).

Table 1. Mean Values of Physico-Chemical analysis of water

Parameters	Summer	Rainy	Winter
Temp (^{0}C)	28	27.5	26.5
pH	6.5-7.0	6.5-7.0	6.5-7.0
Turbidity (NTU)	10	17.5	10
TDS (ppm)	230	540	280
Total Hardness (ppm)	110	340	200
$CaCO_3$ Hardness (ppm)	80	190	120
Total Alkalinity (ppm)	210	320	240
Chloride ions (ppm)	25	60	40
Free residual Chlorine	Nil	Nil	Nil
Fluoride (ppm)	0.5	0.5	0.5
Nitrate(ppm)	< 10	< 10	< 10
Iron (ppm)	0.3	0.5	0.5
Silica (ppm)	5	10	5

It is important to measure pH at the same time as chlorine residual since the efficacy of disinfection with chlorine is highly pH-dependent: where the pH exceeds 8.0, disinfection is less effective (Kalra *et al.,* 2012). The turbidity of the water samples collected during rainy season was higher whereas in summer and winter season, it was noted as 10 NTU (EPA 2011). Turbidity in water is caused by suspended matter such as clay, silt, and finely divided organic and inorganic matter, soluble coloured organic compounds, plankton and other microscopic organisms (Khalid *et al.,* 2011). TDS values of water samples provided by tankers in rainy season were higher than 500 mg/l prescribed by WHO (2004). During festival season immersion of idols in urban water bodies have grown in number and size over the years. Also due to pollution and discharge of effluents into the water bodies without undergoing proper treatment process, the urban water bodies are facing an increasing nutrient load (WHO 2004). Total Hardness is defined as the sum of the calcium and magnesium concentrations, both expressed as calcium carbonate, in ppm. The value of total hardness for samples from Mumbai area fluctuates from 40 ppm to 460 ppm. It was due to the presence of $CaCO_3$ hardness. For some of the localities in this region the measured value of total hardness for rainy season increased to 460 mg/l, which is above the prescribed limit of 300 mg/l by WHO, thereby, making it unsuitable for consumption (WHO 2004). In all the samples collected, presence of free residual chlorine was not detected. The absence of a chlorine residual in the distribution system may, in certain circumstances, indicate the possibility of post-treatment contamination. Water samples should therefore be analyzed for free chlorine. The concentration of iron detected in the water samples in Rainy and winter season was 0.5 ppm. As per WHO (2004) guidelines for domestic water, iron should not exceed the limit of 0.3 ppm. Above 200 ppm iron is toxic to human health. Presence of excess of iron in water causes discoloration from yellow to brownish black, resulting in turbidity and deposits which becomes objectionable to consumers. It may also impart astringent metallic or bitter taste. Excess of iron facilitates growth of iron bacteria which causes blocking of pipes, meters etc (BIS 1991). The work carried out by Trivedi *et al.,* (2010) has revealed that for all seasons, the surface water and ground water in Kanpur showed high turbidity. However, the other physico-chemical parameters were reported to be within highest desirable limit (HDL) prescribed by WHO for drinking purposes.

Bacteriological Analysis

The isolation and enumeration of coliforms indicate the presence of faecal contamination (Wu *et al.,* 2011). They may also be used to assess the efficiency of drinking-water

Table 2. MPN of tanker water

	Summer	Rainy	Winter
MPN/100 ml	1800+	1000	25

Table 3. Morphological, Biochemical, Serological characteristics of the isolates obtained

Isolate	Characteristics	Organism Identified
1.	Lactose non-fermentor, H_2S producing, gram negativerods, non-endospores forming, motile organisms,shows agglutination with Salmonella O antisera	*Salmonella*
2.	Lactosefermentor, gram negativeshort rods, non-endospores forming, motile organisms, shows greenish metallic sheen on EMB agar	*E.coli*
3.	Lactose fermentor, gram negative short rods, non-endospores forming, capsulated, non-motile organisms, shows pink, mucoid colonies on EMB agar	*Klebsiella, Enterobacter*
4.	Spore forming, gram positive rods in chains, opaque white colony on Nutrient Agar	*Bacillus*
5.	Gram negative rods, non-endospores forming, shows bluish green diffusible pigment in NA and NB, oxidase positive	*Pseudomonas*
6.	Gram negative curved rods, yellow colonies on TCBS, oxidase positive, actively motile	*Vibrio*

Table 4. Occurrence of bacterial strains in tanker water samples collected during different season

	Number of samples showing growth		
Organisms	Summer	Rainy	Winter
Salmonella	12	10	7
E.coli	18	16	15
Klebsiella, Enterobacter	9	11	8
Bacillus	14	16	9
Pseudomonas	2	Nil	Nil
Vibrio	4	2	Nil

treatment plants, which is an important element of quality control (Abera *et al.,* 2011). Drinking such contaminated water or using it in food preparation may cause new cases of infection. To prevent or to reduce the appearance of waterborne diseases, many countries provide monitoring programs based on international and/or national regulation standards. It is important to create awareness of the importance of chlorination. The drivers are advised to keep the tankers clean. Private water suppliers must be subjected to random checks to ensure water quality.

The coliform count of the water samples supplied by the tankers in all the seasons was found to be very high which far exceeds the WHO (2003) standards (Table 2). Out of the total 75 samples of tanker water collected throughout the year, only a few samples showed absence of coli forms. During present study, six bacterial strains, were isolated and identified on the basis of their morphological, cultural and biochemical characteristics (Table 3). This can result in the high incidence of water-borne diseases such as dysentery, diarrhea and typhoid fever (Mara 2011; Ojo 2007). Season wise occurrence of the organisms was also studied as reported in Table 4. Maximum bacterial load was observed for the water samples analyzed during summer season, 18 samples were found to be not potable. Pathogens like *Pseudomonas* and *Vibrio* were also detected in samples collected during summer season. The higher values of bacterial population recorded during summer might be due to increased ambient temperature which favours the growth of bacteria. The work carried out by Wu *et al.,* (2011) showed that wet weather leads to sharp increase of *E. coli* densities in urban watershed. This is in correlation to high MPN count of water samples noted during rainy season. The lower value during winter can be explained on the basis of lower multiplication and poor growth due to low temperature (Shrivastava *et al.,* 2014) The water samples collected during rainy season with high amount of turbidity and TDS value were reported to contain organisms like *Salmonella* and *E.coli*(Raibole and Singh 2011).

Conclusion

Considering status of water-borne diseases in India, the present study is highly significant to determine threats associated with drinking polluted water provided by tankers. With increasing population in city like Mumbai water is becoming scare and people are ready to accept water from any sources. BMC also doesn't pay much attention to the quality of this water from others sources. This study throws light on connection between water-borne diseases and tanker water as claimed by BMC. The analysis of the tanker water samples collected from different locations during different seasons provides a better understanding of the growth of microbiological populations in drinking water in correlation with physicochemical parameters. Samples collected during summer and rainy seasons were reported to have high bacterial count. This can be correlated with the temperature and the presence of organic matter in the water. Pathogens that were detected in the present study are *E.coli, Salmonella, Vibrio, Pseudomonas, Enterobacter, Klebsiella, Bacillus*. A strong correlation was observed between turbidity of the samples and coliform counts. A higher values of total coliforms was noted in samples with high turbidity. It has to be emphasized that usually precipitated iron can cause turbidity. In most of the samples with high turbidity, elevated values of total iron were determined. The relationship between free residual chlorine and the micro-organisms is also an important parameter. Chlorine, when used as a disinfectant. leaves a residual that assists in preventing recontamination during distribution, transport, and household storage of water. The absence of free residual chlorine in the samples possibly explains the presence of coliforms in it.

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