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Original Research

Status of Physicochemical and Microbiological Quality of Drinking-Water and Its Public Health Significance

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Abstract

A total of 122 samples of drinking water from different sources were collected and assessed for their physicochemical and microbiological quality. A slightly yellowish gross appearance and an abnormal odour were noticed in 10 samples. The pH of drinking-water samples was found in a range of 6.2 - 8.8. The water hardness and residual free chlorine in drinking water were found in a range of 70 - 380 ppm and 0.1 - 1 ppm, respectively. The standard plate count, total coliform count and E. coli count was found in the range of 4.0 x 10 2 – 7.0 x 107, < 2.0 – > 1.8 x 103 and 0.0 – 8.1 x 101, respectively. The eggs of Strongylus spp., Entamoeba hystolytica, and Giardia lamblia were found in 2, 1, and 3 samples, respectively. The values of physicochemical and microbiological parameters in 35 samples were found beyond the permissible limits that mean not safe for drinking purposes.

Keywords: Drinking-Water, E. coli, Hardness, Parasite egg, pH, Residual Free Chlorine, Total Coliform

Introduction

Water is essential to sustain life, and an adequate, safe and accessible supply must be available to all. Improving access to safe drinking-water can result in tangible benefits to health (WHO, 2006). The great majority of evident water-related health problems are the result of microbial (bacteriological, viral, protozoan, or other biological) contamination. Nevertheless, an appreciable number of serious health concerns may occur as a result of the chemical contamination of drinking water (WHO, 2006). The quality of drinking water has always been a major health concern, especially in developing countries, where 80 % of the diseases are attributed to inadequate sanitation and the use of polluted water (Yasin *et al.*, 2015). The inaccessibility of potable water to a large segment of a population in the rural communities is the major public health concern in most part of developing countries (Yasin *et al.*, 2015).

The health concerns associated with chemical constituents of drinking water arise primarily from the ability of chemical constituents to cause adverse health effects after prolonged exposure. Physical, chemical, and microbial constituents of water may affect the appearance, odour or taste of the water and the consumers evaluate the quality and acceptability of the water on the basis of these criteria. Although these substances may have no direct health effects, water that is highly turbid, is highly coloured or has an objectionable taste or odour may be regarded by consumers as unsafe and may be rejected (WHO, 2006).

It is necessary to know the pH of water because water with higher pH (more alkaline) requires a longer contact time or a higher free residual chlorine level at the end of the contact time for adequate disinfection. The optimum level of free residual chlorine is 0.4–0.5 mg/litre at pH 6–8, 0.6 mg/litre at pH 8–9; but chlorination may be ineffective above pH 9 (WHO, 2006). Acidic water supplies may cause the dissolution of lead from lead pipes and fittings or solder which may result in elevated lead levels in drinking water, which cause adverse neurological effects. Public acceptability of the degree of hardness of water may vary considerably from one community to another, depending on local conditions. Water with hardness above 200 mg/litre may cause scale deposition in the treatment works, the distribution system and pipework, and tanks within buildings. Soft water, with a hardness of less than 100 mg/litre, has a low buffering capacity and so be more corrosive for water pipes. Chlorine is widely used as an important disinfectant both industrially and domestically. In water, chlorine reacts to form hypochlorous acid and hypochlorites (WHO, 2003).

Faecally derived pathogens are the main concerns in setting health-based targets for microbial safety. Monitoring of microbiological quality of drinking water relies largely on the examination of indicator organisms such as coliforms and *Escherichia coli*. The total coliform count is widely regarded as a reliable indicator of potable water quality. *E. coli* is a member of the faecal coliform group and is a more specific indicator of faecal pollution than other faecal coliforms (Odonkor and Ampofo, 2013). About 85–95% of human infections with *E. histolytica* are asymptomatic (Marshall *et al.,* 1997). *Giardia* can multiply in a wide range of animal species, including humans, which excrete cysts into the environment. The present study was undertaken to assess the physicochemical and microbiological quality of drinking water from different sources like hand pumps, university campus water supplies, municipal water supplies, and domestic water filters in Ayodhya and Sultanpur districts of Uttar Pradesh.

Materials and Methods

A total of 122 samples of drinking-water from different sources comprising hand pumps (64), university campus water supplies (23), municipal water supplies (20), and domestic water purifiers (15) were collected between the period 2018 and 2021from different areas in Ayodhya and Sultanpur districts of Uttar Pradesh. All the samples were collected aseptically as per the methods described by Senior (1996), transported to the laboratory within 2 hours, and kept under refrigeration until completion of the processes.

All samples were subjected to physicochemical assessment comprising gross appearance, odour, pH, hardness, and residual free chlorine as per the methods described by the BIS (1991). The microbiological quality of drinking water was assessed by using standard plate count, total coliform count, and *E. coli* count as per the method described by Senior (1996). Standard plate count, total coliform count, and *E. coli* count were performed by using yeast extract agar (Himedia), MacConkey broth (Himedia), and brilliant green lactose bile broth (Himedia), respectively.

For standard plate count, the samples inoculated plates were incubated at 37^0C for 24 hours and the result was estimated per ml of the water sample. The total coliform count and confirmed *E. coli* count was determined as per method described by Senior (1996). Most Probable Number (MPN) values per 100 ml of sample for three sets of tubes each of five tubes seeded with a 10 ml, 1 ml or 0.1 ml volume of the sample. Confirmed *E. coli* count was determined by using Eijkman test. All drinking-water samples were also screened for the presence of parasitic eggs as per the methods described by Rafiei *et al.* (2014). One litre of each drinking water sample was allowed to stay undisturbed for 24 hours, then the supernatant was gently removed by aspirating with a pipette and the sediment was examined under a microscope for parasitic cysts and eggs. The smears made from sediments were stained with Lugol's iodine and modified Ziehl-Neelsen acid fast stain to enhance the visualization of parasitic cysts and eggs.

Results and Discussion

In the present study, the physicochemical parameters for assessment of drinking water included were gross appearance, odour, pH, hardness, and residual free chlorine. A slightly yellowish gross appearance was noticed in drinking-water samples from hand pumps, university campus water supplies, and municipal water supplies in 5, 2, and 3 samples, respectively (Table 1). The abnormal odour was noticed in drinking-water samples from hand pumps, university campus water supplies, and municipal water supplies in 7, 1, and 2 samples, respectively (Table 1).

Table.1: Physicochemical Status of Drinking-Water Samples

S.N.	Source of water (Number of samples)	Gross appearance	Odor	pH (Mean value)	Hardness in ppm (Mean value)	Residual free chlorine in ppm (Mean value)
1	Hand pumps (64)	Normal: 59 Slightly yellowish: 5	Odor-free: 57 Abnormal odor: 7	6.2 – 8.8 (7.4)	240 – 380 (310)	Not tested
2	University campus water supplies (23)	Normal: 21 Slightly yellowish: 2	Odor-free: 22 Abnormal odor: 1	7.0 – 7.8 (7.2)	160 – 310 (280)	0.0 – 1.0 (0.5)
3	Municipal water supplies (20)	Normal: 17 Slightly yellowish: 3	Odor-free: 18 Abnormal odor: 2	6.8 – 8.2 (7.4)	320 – 380 (340)	0.0 – 1.0 (0.2)
4	Domestic water purifiers (15)	Normal	Odor-free	7.0 – 7.4 (7.2)	70 – 280 (120)	0.0 – 0.2 (0.1)

The pH value of drinking water from hand pumps, university campus water supplies, municipal water supplies, and domestic water purifiers was found in the ranges of 6.2-8.8, 7.0-7.8, 6.8-8.2, and 7.0-7.4, respectively (Table 1). Out of 122 drinking-water samples, the pH of 114 samples was found within the permissible limit as per the guideline of WHO (1996), one sample exhibited lower value and seven samples exhibited higher pH values. Misra and Belapurkar (2004) and Jain *et al.* (2004) reported the pH of drinking water in the range of 6.7-7.8 and 6.5-8.0, respectively. In the present study, the lower pH value of drinking-water was might be due to the release of carbon dioxide into the water as a result of the decomposition of organic matter and living things, while, the higher pH value in few drinking-water samples might be due to the presence of soil or bedrock containing carbonate, bicarbonate, or hydroxide compounds around groundwater sources. Both the lower pH (< 6.5) and the higher pH (> 8.5) values of water are not suitable for drinking purposes.

The hardness of drinking water from hand pumps, university campus water supplies, municipal water supplies, and domestic water purifiers was found in the range of 240-380, 160-310, 320-380, and 70-280 ppm, respectively (Table 1) in which higher values of water hardness was found in 120 samples. The present study indicates the presence of a higher level of hardness in drinking water from the area of study. Sharma and Vinay (2008) reported 220-440 ppm hardness of water from a hand pump which is comparatively higher than our findings, which might be due to variation in the mineral salt contents in the water from different geographical locations. In the present study, the hardness of drinking water from all sources was found higher than the permissible limit as per the guidelines of the WHO (1996). There are no serious adverse health problems associated with drinking hard water. However, hard water contains a large amount of calcium that can interact with iron, zinc, magnesium, and phosphorus within the intestine, thereby reducing the absorption of these minerals. Hard water may cause skin dryness and irritation, and eczema. Hard water may also affect its acceptability to the consumer in terms of taste and scale deposition.

The residual free chlorine in water indicates the status of disinfection especially chlorination. In the absence of chlorine residuals, the microorganisms may survive and grow enormously and regular measurement of chlorine residues in the water supply may, in part, replace bacteriological surveillance. The residual free chlorine value in drinking water from municipal water supplies, university campus water supplies, and domestic water purifiers was found in the range of 0.0-1.0, 0.0-1.0, and 0.0-0.2 ppm, respectively (Table 1). As per the guideline of WHO (1996), 0.5 ppm of residual free chlorine in water is desirable. A lower concentration of residual free chlorine in the water may lead to improper disinfection, while a higher concentration may alter the taste of water.

The standard plate count (SPC), total coliform count, *E. coli* count, and detection of parasitic eggs in drinking water from different sources were carried out to assess the microbiological quality of drinking water. The standard plate count (SPC) reflects the sanitary quality of water. In the present study, the standard plate count (SPC) in drinking water from hand pumps, university campus water supplies, municipal water supplies, and domestic water purifiers was found in the range of $1.2 \times 10^4 – 2.2 \times 10^7$, $2.1 \times 10^5 – 5.0 \times 10^7$, $1.0 \times 10^6 – 7.0 \times 10^7$ and $4.0 \times 10^2 – 2.0 \times 10^5$ per ml, respectively (Table 2) in which higher counts were observed in 35 samples that were not safe for drinking purpose. Prejit *et al.* (2006) reported standard plate count in drinking-water samples in the range of 3.6×10^1-1.2×10^5 per ml, which is almost similar to our findings.

Table 2: Microbiological Status of Drinking-Water Samples

S.N.	Source of water (No. of samples)	SPC per ml (mean value)	Total coliform count per 100 ml (mean value)	*E. coli* count per 100 ml (mean value)	Parasite egg (present in No. of sample)
1	Hand pumps (64)	$1.2 \times 10^4 – 2.2 \times 10^7$ (8.0×10^5)	< 2.0 – > 1.8×10^3 (1.0×10^2)	0.0 – 7.2×10^1 (1.0×10^1)	Nil
2	University campus water supplies (23)	$2.1 \times 10^5 – 5.0 \times 10^7$ (1.2×10^6)	< 2.0 – > 1.8×10^3 (1.2×10^2)	0.0 – 1.4×10^1 (1.1×10^1)	*Strongylus* spp. (2)
3	Municipal water supplies (20)	$1.0 \times 10^6 – 7.0 \times 10^7$ (4.5×10^6)	2.0 – > 1.8×10^3 (1.4×10^2)	0.0 – 8.1×10^1 (1.3×10^1)	*Entamoeba hystolytica* (1) *Giardia lamblia* (3)
4	Domestic water purifiers (15)	$4.0 \times 10^2 – 2.0 \times 10^5$ (3.0×10^3)	5.0 – 1.4×10^1 (1.0×10^1)	0.0 – 1.0×10^1 (0.2×10^1)	Nil

The coliform bacteria occur in the environment and in the feces of all warm-blooded animals and humans. The presence of coliform bacteria in drinking water indicates that pathogens could be in the water system. In the present study, the total coliform count in drinking-water from hand pumps, university campus water supplies, municipal water supplies and domestic water purifiers was found in the range of < 2.0 – > 1.8×10^3, < 2.0 – > 1.8×10^3, 2.0 – > 1.8×10^3 and 5.0 – 1.4×10^1, respectively (Table 2). Sharma *et al.* (2006) reported coliform count as 0.2×10^2 per 100 ml which is lower than the present findings. Sila (2019) reported a total coliform count in the water sources in a range of 0.0 to 3.43×10^4 per 100 ml. The higher range of total coliform count in drinking water in the present study was might be due to contamination from livestock facilities, manure lagoons, household wastewater, the poor management system of the water supplies, and inadequate and irregular disinfection of drinking-water.

E. coli count in drinking water from hand pumps, university campus water supplies, municipal water supplies, and domestic water purifiers was found in the range of 0.0 – 7.2×10^1, 0.0 – 1.4×10^1, 0.0 – 8.1×10^1, and 0.0 – 1.0×10^1, respectively (Table 2) in which 35 samples exhibited the presence of *E. coli* that rendered the water unsafe for drinking purpose. Singh *et al.* (2018) reported *E. coli* in a range of 3 – 28 per 100 ml water. Sila (2019) reported *E. coli* count in the water sources in a range of 0.0 to 34.79 per 100 ml. The findings of these researchers are almost similar to the findings of the present study. The presence of *E. coli* in the drinking-water supplies usually indicates recent fecal contamination. That means there is a greater risk that pathogens are present. The presence of *E. coli* in the drinking-water supplies may cause various types of infections including diarrhoea, haemorrhagic colitis (HC), haemolytic uraemic syndrome (HUS) and thrombotic thrombocytopenic purpura (TTP) in the consumers.

The university campus water supplies showed the presence of eggs of *Strongylus* spp. in 2 samples, and municipal water supplies showed the presence of eggs of *Entamoeba hystolytica* and *Giardia lamblia* in 1 and 3 samples, respectively. The presence of these parasitic eggs in the drinking-water samples was might be due to contamination of water with sewage that may adversely affect the health of consumers.

Conclusion

The present study has revealed that the values of physicochemical and microbiological parameters of many drinking-water samples were beyond the maximum permissible limits that may adversely affect public health. Therefore, it is important to develop adequate, safe, and accessible water supplies, improve the existing infrastructures and take appropriate measures for hygienic water supplies, including sanitary awareness among the public.

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Conflict of Interests

There is no conflict of interest.

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