GREEN CROSS PUBLICATIONS
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Research Pharmaceutica, 2(2), 2018, 07-10

RESEARCH Pharmaceutica

Research Article

ISSN No: 2457-0389 (Online)

COMPARATIVE QUALITY: A QUANTITATIVE APPROACH FOR SAFE DRINKING WATER

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www.greencrosspublications.com

An Official Publication of SKB College of Pharmacy, Kamptee

ARTICLE INFO

Date of Submission: April 14, 2018
Date of Revision: May 01, 2018
Date of Acceptance: May 28, 2018

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KEYWORDS

Water, Well, Bore-well, River, Reverse osmosis, Ultra-violet.

ABSTRACT

Having safe drinking water and basic sanitation is a human need and right for every man, woman and child. Still millions of people are exposed to unsafe levels of chemical contaminants in their drinking water, which have been associated with serious health implications. WHO in 1948 come up with an objective of promoting 'the attainment by all peoples of the highest possible level of health.' In milieu, water from natural sources such as River, Well, Bore-well, purified by means of electric equipment Reverse Osmosis (RO) and Ultra-violet techniques, provided by Municipal Corporation (MC), and Packaged Drinking Water (PDW) were comparatively and quantitatively evaluated from Kamptee region (21.333°N, 79.2°E).

All parameters were evaluated as per BIS 10500, pH of water samples were found to be within limit (6.5 to 8.5). Odour was agreeable except well and river which smells chlorinous and fishy respectively. Turbidity limit (10 NTU) was crossed by river, well and bore-well samples. Hardness was within the acceptable limit (200 mg/L) while undesirable substances such as calcium, chloride, nitrogen, copper, magnesium were within the specified limit 75 mg/L, 250 mg/L, 45 mg/L, 0.05 mg/L, 30 mg/L respectively whereas sulphate content obersered higher in river, well and bore-well samples. Mercury was under limit (0.001 mg/L). Microbiological study revealed that all water samples were safe except water from natural sources. Comparative and quantitative evaluation of water samples from different sources showed that RO, UV, MC, PDW water samples are the best sources for water consumption. Considering health, water with depleted minerals obtained from RO not fit for drinking, so such depletion of minerals was fulfilled by mixing municipal corporation (MC) water in ratio of 80:20 (RO: MC) showed best source for drinking irrespective to taste, odour, turbidity, mineral contents and microbial contamination.

1. INTRODUCTION

Water is essential to life and a nominal supply of clean safe drinking water is required for the sustenance of life. WHO is to establish international norms to protect human health? Since 1958, as part of its activities on drinking-water and health, the organization has published –several editions of International Standards for Drinking-water and subsequently, the Guidelines for Drinking water Quality.1 Different processes and technologies such as the bios and filter, ceramic filter, solar disinfection (SODIS) and chlorination are being introduced from different governmental and non-governmental organizations (NGOs) to provide safe drinking water for human consumption.

The safety of water resources is of pressing importance worldwide because millions of people are exposed to unsafe levels of chemical contaminants in their drinking water, lot of serious health problem. In milieu, water from natural sources such as river, well, bore-well, purified by means of electric equipment i.e. reverse osmosis (RO) and ultra-violet techniques, provided by Municipal Corporation (MC), and packaged drinking water (PDW) were comparatively and quantitatively evaluated for organoleptic properties, undesirable substances, toxic substances and microbial examination from Kamptee region. [2,3]

2. MATERIALS AND METHODS

Material which includes chemical, media and reagents such as Neocuproine, Hydroxylamine Hydrochloride, Chloroform, Sodium citrate, Silver nitrate, Potassium chromate, etc were procured from Sigma Aldrich laboratories and Hi-media laboratories. Methods such as UV/Vis spectroscopy, nephelometry, titrimetry and microbial examination were performed as per Bureau Indian Standard (BIS) 10500 specification.

Plastic bottles of 1L and glass bottles 250mL capacity were used for collection of water sample for Organoleptic and bacteriological testing respectively. Water samples were collected with utmost care to ensure that no contamination occurs at the time of collection or prior to examination[4,5]

3. RESULTS

Organoleptic parameters which include pH, odour, turbidity, hardness and taste were performed; the pH of all samples was within limit fluctuate between 6.645±0.0775 (RO) to 8.413±0.1205 (River). Odour was agreeable except well and river which smells chlorinous and fishy respectively. Turbidity of all samples fell within the permissible limit i.e. 10 NTU whereas river, well, bore-well were 12.40±0.1155, 12.20±0.1606 and 11.98±0.0104 respectively were out of limit.

Water samples of RO, MC, UV and PDW falls in soft category in respect to hardness while River, well and bore-well fall in the moderately hard category 60-120 mg/L even though BIS acceptable limit is 200 mg/L. Calcium content in water samples was found to be within limit 75 mg/L with lowest in RO 9.61 mg/L. Chlorine content in water samples are within limits i.e. 250 mg/L, it fluctuates from 7.6 to 47.29 with well containing the highest concentration of chloride. Nitrogen content in all the water samples analyzed are within the specification limit except well which shows little higher concentration compared to other. Sulphate content in RO, MC, UV, PDW, Bore-well samples are within the permissible limit 200-400 mg/L., but observed above in river and well. Magnesium content in water samples were found to be under the BIS specification limit 30 mg/L. Mercury content in all water samples were within the acceptable limits. Bacteriological testing of water samples showed that there was no coliform growth in samples of RO, UV, MC, PDW because water from these sources are passed through membrane filter (pore size: 0.22 to 0.45 m) from bacteria are unable to pass. Samples of river, bore-well, and well showed presence of coliform bacteria. The Most Probable Number (MPN) of coliform in bore-well and well was 30 and 8 respectively and river sample was Too numerous to count (TNC)

4. DISCUSSION

The present study designed for comparative evaluation and estimation of safe and healthy drinking water. So various water quality parameters, such as Organoleptic parameters, undesirable substances, toxic substances and microbiological examination were evaluated as per Bureau of Indian Standards (BIS 10500, 1992).6

Organoleptic parameters includes pH, turbidity, odour, hardness, taste are importance. BIS standard states that pH7 of drinking water should be between 6.5-8.5 and all water samples fluctuate between 6.5 to 8.10. Variations in pH value from 7.0 are mainly due to hydrolysis of salts of strong bases and weak acids, or dissolved gases such as carbon dioxide, hydrogen sulphide and ammonia. Odour8 is an important parameter from the point of view for acceptability of drinking. All water samples were agreeable to smell except river that smell fishy because of algae growth and aquatic animals while well waters are usually done disinfection and chlorination to avoid and kill microorganism so it smells chlorinous.

Taste9 is a parameter concerned with a sense for taste. Evaluation of taste was performed from the action tendency scale. Samples to be preferred as everyday drinking water by the volunteers were RO, MC, UV, and PDW. Considering cost, PDW was not chosen as everyday drinking water. Different ratio of RO, MC and UV water was prepared. In which, best ratio selected was RO: MC which fulfils the taste and mineral requirement of humans.

Turbidity10 indicates the estimate of suspended matter. Results showed that turbidity of all samples fell within the permissible limit i.e. 10 NTU whereas river, well, bore-well were out of the limit which was due to the presence of particulate matter that may be present as a consequence of inadequate treatment or from re suspension of sediment in the distribution system.

The hardness11 of water is due to the presence of Ca^{2+} and Mg^{2+} ions in water both expressed as $CaCO_3$ mg/L. Excessive hardness in water produces poor lathering with soap; deterioration of the quality of clothes; scale forming; skin irritation; boiled meat and food becomes of poor quality. Water samples of RO, MC, UV and PDW falls in soft category of hardness while river, well and bore-well fall in the moderately hard category of water of 60-120 mg/L although BIS acceptable limit is 200 mg/L.

Calcium12 plays main role in development and rigidity of human bones otherwise it may cause problems like osteoporosis and rickets. Calcium content in water samples was found to be within limit 75 mg/L with lowest calcium content of RO 9.61 mg/L. Intake of RO water daily may cause development of bone and joints problem, osteoporosis in males and females. It's a crucial point of concern for people drinking RO water daily. So, by mixing RO: MC (80:20) can be a safe and healthy source for drinking water. As the requirement for mineral of RO is fulfilled by MC water.

Chloride13 in drinking-water originates from natural sources, sewage and industrial effluents, urban runoff containing de-icing salt and saline intrusion. Chlorine content in water samples are within limits i.e. 250 mg/L,

Table 1: Organoleptic physical parameters of water samples

Sr. No	Water samples	pH	Odour	Turbidity (NTU)	TH,CaCO3 (mg/ml)
1	River	8.413±0.1205	Fishy	12.40±0.1155	68.43±0.1472
2	Well	7.56±0.1117	Chlorinous	12.20±0.1606	86.68±0.0815
3	Bore well	7.925±0.0538	Agreeable	11.98±0.0104	76.48±0.0910
4	RO	6.645±0.0775	Agreeable	5.647±0.1342	12.55±0.02309
5	MC	8.017±0.01333	Agreeable	7.572±0.0566	47.52±0.1166
6	UV	6.597±0.0662	Agreeable	5.618±0.0589	21.56±0.09460
7	PDW	7.402±0.0917	Agreeable	8.522±0.0395	28.29±0.1211

RO: Reverse osmosis, MC: Municipal Corporation, UV: Ultra-violet, PDW: Packaged Drinking Water

it fluctuates from 7.6 to 47.29 with well containing the highest concentration of chloride.

A Major showed that nitrates are ubiquitous in soils and aquatic environment in association with the breakdown of organic matter by bacteria which mineralize and liberate NO3-.Nitrites 14, 15 can lead to cyanosis and asphyxia (blue baby syndrome) in infants below the age of 3 months. All analyzed water samples were within the specification limit of Nitrate except well which shows little higher concentration compared to other samples.16

Sulphate17 accumulation in water can be from Animal sewage, septic system, and sewage, By-product of coal mining, industrial waste, natural deposits or salt. Sulphate content in RO, MC, UV, PDW, bore-well samples are within the permissible limit 200-400 mg/L. But sulphate content in river and well are above the limits, hence it's a significant finding in the study. Higher concentration of sulphate in water can cause health risk laxatives to consumers if ingested.

Excessive content of magnesium in water can cause poor lathering and deterioration of clothes; enhancing laxative effect with sulphate. All water samples were found to be under the BIS specification limit 30 mg/L.

Ahmed J showed mercury is an extremely toxic metal, it enters the environment mainly through human activities, use of mercury as fungicides, pesticides, etc., also add mercury to the environment. It causes disease of acute mercury poisoning called the "Minemata disease" which causes mental disturbance, loss of balance, speech, sight and hearing difficulty in swallowing and degeneration of brain. Mercury content in all water samples was within the acceptable limits.18,19

According to current USEPA recommendations water is considered safe for drinking if it contains less than one colony per 100 ml of water. The occurrence of coliform detected in water is a direct measurement of deleterious effects of pollution to human health causing typhoid, dysentery, cholera and gastroenteritis. Bacteriological testing of water samples showed that there was no coliform growth in samples of RO, UV, MC, PDW because water from these sources are passed through membrane filter (pore size: 0.22 to 0.45 m) from bacteria are unable to pass. Samples of river, bore-well, and well showed presence of coliform bacteria. The Most Probable Number (MPN) of coliforms in bore-well and well was 30 and 8 respectively and river sample was Too Numerous to Count (TNC) because of human activities of washing and bathing, faecal contamination, & animal excreta. [20-23]

Table 2: Undesirable substances (mg/L) in water samples

Sr. No.	Waters samples	Calcium	Chloride	Copper	Nitrogen	Sulphate	Magnesium
1	River	63.32	40.35	0.000694	402.5	0.0101	1.269
2	Well	64.92	47.29	0.000646	1210.5	0.0127	5.256
3	Bore well	70.54	22.16	0.000636	315.5	0.0087	1.353
4	RO	9.61	7.60	0.00062	6.5	0.0020	0.7176
5	MC	28.85	41.01	0.000626	17.5	0.0036	4.435
6	UV	16.83	15.21	0.000626	39	0.0020	1.135
7	PDW	23.24	17.86	0.000626	60.5	0.0023	1.144

RO: Reverse osmosis, MC: Municipal Corporation, UV: Ultra-violet, PDW: Packaged Drinking Water

Table 3: Concentration of mercury in different source of water sample

Sr. No.	Sample	Mercury (µg/L)
1	River	0.1049
2	Well	0.1101
3	Bore well	0.0976
4	RO	0.0459
5	MC	0.0521
6	UV	0.0511
7	PDW	0.0490

RO: Reverse osmosis, MC: Municipal Corporation, UV: Ultra-violet, PDW: Packaged Drinking

Table 4: Presumptive test for coliform bacteria and colonies

Sr. No.	Sample	Observations	
		Gas Production	No of Colonies
1	River	Yes	TNC
2	Well	Yes	30
3	Bore well	No	10
4	RO	No	Nil
5	MC	No	Nil
6	UV	No	Nil
7	PDW	Yes	Nil

RO: Reverse osmosis, MC: Municipal Corporation, UV: Ultra-violet, PDW: Packaged Drinking Water

5. CONCLUSION

Comparative and quantitative evaluation of water samples from different sources showed that RO, MC, UV, PDW water samples are the best sources for water consumption. Evaluation of water samples considering health showed that only RO water as a source of drinking water was not fit for health. Because long term consumption of single RO water gives various health hazards in future by causing deficiencies of mineral content in human body. So, by mixing 80:20 ratio of RO: MC showed best source for drinking from taste and health parameter. Depletion of minerals caused by RO filters will be fulfilled from MC water and taste acceptance was also met. Sample from well, bore-well and river, have to be undergone further microbial studies for its safe use as they contain coliform bacteria.

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