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Original Research Paper

Assessment of Water Quality in Terms of Total Hardness and Iron of Some Freshwater Resources of Kanpur and its Suburbs

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ABSTRACT

Kanpur, a heavily populated, huge industrial city is reeling under acute water crisis, its pollution and contamination. Urban and suburban inhabitants of Kanpur, with no option in sight and hand, are compelled to use whatsoever source and quality of water is available to them, often felling prey to water related ailments, either knowingly or unknowingly. With this logic in mind the present study was undertaken to assess the water quality of some different water resources of Kanpur and its suburbs, serving as a source of potable water for its denizens. The water quality was assessed in terms of water hardness to adjudge its quality and suitability for human consumption, domestic, industrial or agricultural purposes in the light of available recommended standards. The parameter was so chosen as it is known to be associated with human health, industry and agriculture.

INTRODUCTION

Water quality is a composite expression of the impact of a large number of physical, chemical and biological factors on water. No single parameter can serve as a sole criterion for the overall quality of water for its diverse uses. Water to be used for a specific purpose should specify certain specific standards which vary widely according to its use.

Hardness of water reflects the nature of geochemical formations with which water has been or is in contact. It depends on a complex mixture of both, the cat ions and anions, and is predominantly contributed by carbonates and bicarbonates of Ca^{++} and Mg^{++}. It is an index of its capacity to precipitate soap. Soap is chiefly precipitated by calcium and magnesium ions present in water. Water hardness is directly proportional to the concentration of Ca^{++} and Mg^{++} ions along with some other polyvalent metal ions like iron, barium, manganese and strontium. Besides Ca^{++} and Mg^{++}, other cations are usually present in complex form associated with some organic constituents and their role in causing water hardness is very minimal, negligible and usually difficult to define. Hardness prevents lather formation with soap and produces scales at higher temperatures usually above 60°C. Generally, Ca^{++} and Mg^{++} maintain a state of equilibrium in natural waters (Jain et al. 2011). Calcium and magnesium are major constituents which play an important role in biogeochemical processes in aquatic habitats (Padmavati et al. 2011). Magnesium content of water is also considered as one of the most important criteria in determining quality of water for irrigation. More magnesium in water will adversely affect crop yields as the soils become more alkaline (Jain et al. 2011).

Hardness of water may be of different types. Ca^{++} and Mg^{++} salts combined with carbonates and bicarbonates result in temporary hardness and with sulphates, chlorides and other anions of mineral acids result in permanent hardness. In natural waters, the prime sources of Ca^{++} and Mg^{++} are sedimentary rocks containing minerals like calcites, dolomite and gypsum, and anthropogenic sources are different types of industrial effluents from chemical and mining industries, pulp and paper industries, sugar mills, petroleum refineries, tanning and ceramic industries. Hardness may be in the form of carbonate hardness or non carbonate hardness. When total hardness, numerically exceeds the sum total of carbonate and bicarbonate alkalinity, the amount of hardness equivalent to total alkalinity, is referred as carbonate hardness while the remaining hardness is referred as non carbonate hardness. Similarly, when the total hardness is numerically equal to or less than the sum total of carbonate and bicarbonate alkalinity, all hardness is referred as carbonate hardness and non carbonate hardness is absent (APHA 1995).

In natural waters, hardness usually ranges from 10 to more that 500 mg/L. Values above 500 mg/L are relatively uncommon (EPA 1976). Hardness, though not generally regarded as a pollution parameter, yet is correlated with it (Stocks 1970). United States Geological Survey (USGS) has classified the waters with hardness ranging from 0-61 mg/L as soft, 61-120 mg/L as moderately hard, and 121-180mg/L as hard and with values exceeding 180 mg/L as very hard. As per the WHO (1984) standards, 500mg/L is the maximum permissible limit of hardness in any water to be used as potable water. Waters with hardness values less than 10 mg/L are also not suitable due to their low buffering capacity and more corrosive ability. Hardness of water affects its suitability as potable water or its use in the textile, paper industry, in steam boilers and in water heaters. Hard waters are unsuitable for bathing, washing and laundering but protect the pipe distribution systems from corrosion by forming a thin layer of scale that hampers the entry of heavy metals from the pipe lines into the water. Hard water causes incrustrations in distribution system and lead to excessive soap consumption (Coleman 1976). Magnesium hardness in association with sulphate ions imposes a laxative effect (Abbasi 1998). Variations in the hardness of potable water result in some physiological disorders in human beings due to variations in the osmotic potential of intestinal blood and body fluid (Kakati 2010). A significant correlation has also been reported between hardness and incidences of cardiovascular diseases (Tebbutt 1998). There are evidences to indicate its role in heart diseases (Porter 1974). Due to their high solubilizing potential, ground waters are usually harder than the surface waters.

MATERIALS AND METHODS

Water samples were collected from nineteen different water resources situated in urban and suburban localities of Kanpur district. These resources include fifteen tube wells, two hand pumps and two rivers namely River Ganga and River Pandu flowing on the northern and southern outskirts of Kanpur respectively and receiving domestic, industrial and agricultural pollutants from their catchments areas. Sampling, storage, preservation and analysis of the samples were done as per the standard procedures (APHA 1989). Ethylene diamine tetra acetic acid (EDTA) titerimetric method was used for estimating total hardness, Ca^{++} and Mg^{++}. Carbonate and bicarbonate alkalinity was estimated by titerimetric method to assess the carbonate and bicarbonate hardness of water samples. Total iron was estimated spectrophotometrically using phenonthroline method. Sampling was done twice per season during 2010.

RESULTS AND DISCUSSION

Results of the analysis of different water resources show a wide variation, varying with the source and season (Table 1). Values of hardness ranged from 84 mg/L to 960 mg/L. The peak value was recorded at station 16 (Motipura) which declined to 950 mg/L at station 17 (Shekhpura). Station 11 (Shyam nagar) too reported a value exceeding 360 mg/L. The minimum value was reported at stations 8 and 13 (Rambhagh and Motinagar, Jajmau). In the light of USGS standards mentioned above, it is evident that water is moderately hard at 5 stations, hard at 7 stations and exceptionally hard at 9 stations. As per WHO (1984), desirable limit of hardness in potable water is 100 mg/L. If hard water is used as potable water, it causes undesirable effects on digestive systems (Pitchammel et al. 2009). Thus, it is evident from the results that barring stations 8 and 13, all other water resources have hardness values higher than the prescribed permissive limits and only 20 percent of the water resources examined are up to the mark as per WHO guidelines to be used as potable water source. Sawyer et al. (1967) classified waters on the basis of hardness into three basic categories i.e., waters with hardness values ranging from 0-75 mg/L as soft waters, 75-150 mg/L as moderately hard and 151-300 mg/L as hard. In the light of these standards, the hardness values indicate that none of them is in the category of the soft water, 8 in the category of moderately hard waters, and the remaining 7 in the category of hard waters and 4 in the category of excessively hard water. Besides the potability factor, hardness criterion is taken into account for use of water for domestic and industrial uses. Hardness values exceeding 200 mg/L result in scale formation in the pipeline distribution system. This results in economic loss due to increased consumption of soap and fuel as hardness elevates the boiling point of the water. In the present study, samples from 7 stations showed hardness values exceeding 200 mg/L, thus indicating that they are not even fit for industrial use without proper treatment. Regarding the seasonal periodicity, the values were higher in summer and winters as compared to rains.

Calcium, the most important constituent of bio-skeleton, is essential to maintain the integrity of bones to check osteoporosis. It is essential nutrient which plays an important role in biological systems. The chief source of calcium in natural waters is the passage of water through or over the deposits of lime stones, dolomite, gypsum and gypsiferous shale. In natural waters calcium content may range from nil to several hundred mg/L. In aquatic environment calcium serves as on of the micronutrients for most of the organisms. A low concentration of calcium carbonate combats corrosion of metallic pipes by laying down a protective coating called scale. Higher concentration of calcium salts on the other hand is undesirable as it precipitates on heating at temperatures exceeding 60°C to form scales in boilers, pipes and cooking utensils. In the present study calcium content ranged from 32 mg/L to 230 mg/L (Table 1). Ohle (1938) classified waters on the basis of their Ca^{++} concentration. Waters with Ca^{++} content less than 10 mg/L as poor, with 10.0 mg/L to 25.0 mg/L medium, and with more than 25.0 mg/L as rich. In fact, calcium concentration in water is responsible for the growth of children (Siva Kumar et al. 2003). In the light of this available information it is apparent that water of all the resources was quite rich in calcium contributing to water hardness which is also evident from the recorded hardness values (Table 1).

Table 1: Water characteristics of different water resources.

S.No.	Locations	Total Hardness	Ca^{++}	Mg^{++}	Total Iron	C/N C Hardness
01	Azad Nagar	116.0	32.0	84.0	0.6	C
02	Ghasiyari Mandi	128.0	64.0	64.0	0.6	C
03	Hanspuram	164.0	80.0	84.0	0.4	C+NC
04	Usmanpur	176.0	60.0	116.0	0.4	C
05	Brijendra Swaroop Park	240.0	126.0	114.0	0.4	C+NC
06	Juhi Goshala	130.0	60.0	70.0	0.4	C+NC
07	Keshavpuram	204.0	144.0	60.0	0.2	C+NC
08	Rambhagh	84.0	60.0	24.0	0.4	C
09	Cooper Ganj	120.0	100.0	20.0	0.4	C
10	Kidwai Nagar	170.0	80.0	90.0	0.4	C
11	Shyam Nagar	360.0	74.0	286.0	0.2	C+NC
12	Ravidaspuram	140.0	88.0	52.0	0.4	C
13	Motinagar Jajmau	84.0	40.0	44.0	0.6	C
14	Charan Singh Colony	110.0	70.0	40.0	0.2	C
15	Panki	250.0	126.0	124.0	0.6	C+NC
16	Motipura	960.0	230.0	360.0	0.66	C+NC
17	Sheikhpur	950.0	200.0	350.0	0.7	C+NC
18	River Ganga	178.4	40.67	17.12	0.67	C+NC
19.	River Pandu	840.0	210.0	311.0	0.88	C+NC

All values in mg/L; C= carbonate hardness; N C = Non carbonate hardness

Table 2: Categorization of water resources (as per Sawyer et al. 1967).

Total Hardness, mg/L	Water class	Total Samples	Water class	Sample No.
0.0-75.0	Soft	None	Soft	None
75.0-150.0	Mild Hard	08	Mild hard	1,2,6,8,9,12,13,14
150.0-300.0	Hard	07	Hard	3,4,5,7,10,15,18
> 300.0	Very Hard	04	Very Hard	11,16,17,19

Magnesium, another important contributor to the hardness of waters, ranks 8th among the elements in order of abundance in nature. It is a common constituent of natural waters and is usually present in association with calcium in all kinds of natural waters contributing to the total hardness of water. Its concentration generally remains lower than the calcium (Venkatasubramani & Meenambal 2007). It is an important constituent of plant chlorophyll, and hence acts as an important factor for plant growth and productivity via photosynthesis, hence its concentration in water is significant from agricultural point of view. In this study, Mg^{++} concentration ranged from 20 mg/L to 360 mg/L, the minimum value was recorded at station 9 (Cooper Ganj) and maximum at station 16 (Motipura). Mg^{++} concentration at some of the resources (Stations 1, 4, 11, 16, 17) was 2 to 3 times higher than their corresponding calcium values. As per Bureau of Indian Standards (BIS 1991) 30 mg/L is the permissive limit of magnesium in waters used as potable water. It is thus apparent from the data obtained (Table 1) that except stations 8 and 9, Mg^{++} values at all the rest stations are many fold higher than the permissive limit. The higher concentration of magnesium may probably be due to possible entry of magnesium in the groundwater through leaching or soil structure. So far as the seasonal periodicity is concerned it followed the trend depicted by calcium and hardness with a few variations.

Iron as an essential micronutrient is needed in traces for proper metabolic activities of both plants and animals. It is an essential constituent of cytochromes and non-haem iron proteins involved in various metabolic activities viz., photosynthesis, nitrogen fixation and respiratory linked dehydrogenases (Verma 1991). In natural waters iron may occur in true solutions, in a colloidal state or in the form of inorganic and organic complexes. It may be either in ferric or ferrous state, depending on the dissolved oxygen content of the water. Iron concentration of water is significant as it stains laundry and is objectionable in food processing, dying and other industrial uses. Higher concentration of iron causes haemochromatosis (Rajjak 2009). Iron gets bioaccumulated in living-beings and leads to enhanced respiratory rate, pulse rate, coagulation of blood vessels, hypertension and drowsiness (Rajjak, 2009). Higher concentration of iron in the water indicates its leaching from sludge or sewage into the soil, which gets absorbed on the soil particles and finally leaches into the water. The higher concentration of iron in the groundwater may be due to streams carrying industrial effluents around the areas from where the samples were collected. In groundwaters iron concentrations may range from 0.5 to 100 mg/L. ISI (1983) and WHO (1984) have set a limit of 1mg/L for potable water. In the present study iron concentration ranged from 0.2 mg/L to 0.6 mg/L which is lesser than the prescribed value.

CONCLUSION

A critical perusal of the study revealed that all the water resources investigated fall short of the desirable or recommended values of ISI and WHO standards. They need to be used as a source of potable water with caution. Out of the 19 samples, none is a resource of soft water. Eight resources are with mild hard waters and can be used directly as potable water source to some extent. While remaining 7 (hard water) and 4 (very hard water) water resources (Table 2) can be used as potable source of water after due treatment, either at Government level or by inhabitants of that area using a standard water purifier to save them from unnecessary health hazards, if not now but in coming future too, as the continuous use of this hard/very hard water may result in diverse health complications.

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