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Spatio-temporal variation of drinking water in district Jammu of J&K, India

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Abstract
A study was conducted to evaluate physico-chemical properties of drinking water in Jammu district of Jammu and Kashmir. A total of 112 water samples from Tawi river pre filtration water, post filtration water, household supply water, water of ponds and wells in *kandi* area and border belt in summer and rainy season were collected. The observed values were compared with recommendations of WHO and ISI to draw inferences. Water temperature varied from 20.25 ^{0}C (Households) to 38.15 ^{0}C (Tawi river) in summers and 28.08 ^{0}C (ponds and wells of kandi area) to 29.4 ^{0}C (households) in rainy season. The pH ranged from 6.6 (ponds and wells of kandi area) to a maximum of 7.94 (Tawi river) in summer and 6.85 (ponds and wells of kandi area) to 7.93 (ponds and wells of border belt) in rainy season. The pH was found to be below the permissible limit in the ponds and wells of kandi area in both the seasons according to WHO standards. Maximum level of chloride was found in the ponds and wells of border belt in the rainy season which was 34.78 mg/l. The magnesium hardness was found to be above the permissible limit according to the Indian standards. The values of nitrate-nitrogen, dissolved oxygen (DO) and FCO_2 recorded were in normal range in the waters evaluated. It was concluded that all the parameters were within the parameters set for pH, temperature, hardness, chloride, nitrate, nitrite, dissolved oxygen and free carbon dioxide, except for magnesium, which was above the permissible limit in both summer and rainy seasons in Tawi river water.

Keywords: Water, physico-chemical, river, Jammu Tawi

Introduction
Pure water is one of the priceless, indispensable and primary drivers of public health. Water quality is an issue of concern for human and animal health in developing as well as in developed countries all over the world [1]. Despite massive outlays for water sanitation in India, access to safe drinking water remains a challenge. Modernization has led to production of wastes which corrode our environment, and as the days go by there is addition of more and more harmful products in our environment. Deteriorated water quality poses a key risk to human and animal health thus demanding regular studies to keep a track of water quality in any region. India ranks 120th out of 122 nations based on quantity and quality of freshwater, waste water treatment facilities as well as legal issues such as the application of pollution regulations, far below the neighbouring countries like Bangladesh (40th), Sri Lanka (64th), China (84th) and Pakistan (80th) [2]. Four percent of deaths and 5.7 percent of the global disease burden is linked to unsafe water consumption [3]. The major diseases that are attributed to environment pollution and poor drinking water supply include Cholera, Shigellosis, Diarrhoea due to *E. coli*, Poliomyelitis, Typhoid, water borne viral hepatitis etc. Major sources of hazard in drinking water supplies affecting its physio-chemical quality are agricultural land wash, domestic sewerage, industrial effluents, improper storage and handling. As such the constant monitoring of drinking water quality becomes imperative as a safeguard against various hazards associated with such drinking water. The detection of various indicator organisms *viz. Coliforms*, faecal *Streptococci* and *Clostridium perfringens* in water, above the permissible limits, is suggestive of faecal pollution as well as portability of water [4]. Despite the fact that water plays an essential role in ecosystem, it is being continuously polluted due to increased human activity. Hence it becomes necessary to understand the physico-chemical qualities of water as these parameters determine the quality of drinking water. Total dissolved solids, pH, hardness, dissolved oxygen, free carbon dioxide are some of the significant parameters to study the quality of water.

As in most part of India, the ponds, rivers, canals, wells, etc. are also the common water sources in Jammu catering the needs of both man and animals. However, the portability and hygienic status of these water sources is not adequately assessed except for few studies [5, 6] with no reference to seasonal variation. As such there was need to carry out analysis of drinking water quality in Jammu including water scarce *kandi* areas.

Materials and methods

A total of 112 water samples, 300 ml in quantity were collected in sterilized neutral glass bottles provided with ground glass stoppers and the neck protected by aluminium foil. The samples were collected following the standard procedure of American Public Health Association [7]. The samples of treated water were collected in sampling bottles added with a sufficient quantity of sodium thio-sulfate (@ 0.1ml of 3% solution in 170 ml sample) to neutralize residual chlorine or chloramines before sterilization. Water was analyzed for phycio-chemical properties like temperature, pH, chloride, hardness, nitrates, nitrites, dissolved oxygen and free carbon dioxide in summer and rainy season to study the quality of water. The samples were collected randomly from Tawi River (Pre filtration), post filtration (Sitlee filtration plant), the household supplies and the ponds and wells of kandi area and border belt. Sixteen water samples from Tawi river (Pre filtration), sixteen post filtration, twelve from household supplies, six from ponds and wells of kandi and border are in both summer and rainy season were collected and analyzed. The data generated throughout the experimental period was analyzed statistically by applying the Completely Randomized Design to study variation in parameters [8].

Results and Discussion

To study the physico-chemical characteristics of water 112 samples were collected at different places and seasons of district Jammu of J&K (Table 1). The results were compared with the standards of WHO and ISI to draw the inferences (Table 2). Temperature is the most important factor which influences the chemical, biochemical and biological characteristics of the aquatic ecosystem. It also alters the saturation values of solids and gases in water [9]. During the course of present investigation on the water samples from Tawi river, post filtration, household and ponds and wells of *kandi* and border area, it was observed that the water temperature (^{o}C) on an average fluctuated between 20.25±0.591 (household) to 38.15±0.423 (Tawi river) during summer season and 28.08±0.583 (ponds and wells of *kandi* area) to 29.46±0.327 (household) during rainy season. Temperature is the measure of intensity of heat stored per volume of water and is highly correlated with atmospheric temperature and morphometric feature of the water body. It is an important biologically significant factor which plays an important role in affecting the metabolic activities of the organisms and physico-chemical properties of water were discussed by [10].

The pH which defines the negative logarithm of hydrogen ion concentration of the aquative environment is suggestive of the acid base equilibrium achieved by various dissolved compounds [11]. The pH of water samples from Tawi river, post filtration, household and ponds and wells of *kandi* and border area revealed the mean values of pH fluctuating from a minimum of 6.6±0.264 (ponds and wells of *kandi* area) to a maximum of 7.94±0.045 (Tawi river) during summer season and 6.89±0.245 (ponds and wells of *kandi* area) to 7.93±0.039 (ponds and wells of border belt) during rainy season. Tawi in the vicinity of Jammu City remained alkaline throughout the study period. It has been well documented that pH in lotic waters undergo quick changes occurring to dilution from show melts and influx of water as a consequence of rains [12]. The slightest variation in pH recorded presently may be due to high buffering capacity of water. As evident relatively low values of pH may be due the increased temperature as suggested by [13].

Chlorides occur naturally in all types of water and one of the major inorganic anions in water [14]. Chloride is widely distributed in nature and enters into the natural water through dissolution of salt deposits. The ecological significance of chloride lies in its potential to regulate salinity of water and exert consequent osmotic stress on biotic communities [15]. The mean value of chlorides (mg/l) varied from a minimum of 8.97±0.215 (post filtration) to a maximum of 27.96±2.37 (Tawi river) during summer season and 8.65±0.287 (post filtration) to 34.78±2.47 (ponds and wells of border belt) during rainy season. The high concentration of chloride is considered to be an indicator of pollution associated with high organic wastes of animal, discharge of effluents from chemical industries, domestic sewage effluents, run off from agricultural fields through fertilizers, organic decomposition and use of soaps and detergents [14].

Calcium is as important micronutrient required for metabolic processes in all living organize and as a structural or skeletal material in many. Besides, calcium also plays a role in buffering pH and the CO_3^{--}, HCO_3^{-} system in the water bodies [16]. The investigations revealed that the mean value of calcium (mg/l) concentration fluctuated between 18.8±1.35 (ponds and wells of border belt) to 34.0±1.33 (post filtration) during summer season and 23.34±1.139 (Tawi river) to 43.27±3.289 (household) during rainy season.

Magnesium is required by chlorophyllus plants as the magnesium porphyrin component of the chlorophyll molecules and as a micronutrient in enzymatic transformation of organisms [17]. The mean values magnesium (mg/l) fluctuated between 5.45±0.218 (household) to 30.37±1.87 (Tawi river) during summer season and 6.0±0.13 to 32.08±3.38 (ponds and wells of border belt) during rainy season. Magnesium has a high solubility than calcium and moreover the demand of magnesium in metabolises of organisms is low as a result of which, magnesium concentration is relatively conservative and therefore exhibits less fluctuation both in soft as well as hard water bodies [18]. It adds to the total hardness of water together with calcium.

Nitrate in surface water is an important factor for water quality assessment [19]. Nitrate represents the end product of oxidation of nitrogenous matters and its presence may depend upon the nitrification and de-nitrification activities of microorganisms, stream currents and catchment characteristics [20]. The mean values of nitrate-nitrogen (mg/l) varied from 0.34±0.035 (Tawi river) to 0.83±0.049 (ponds and wells of *kandi* area) during summer season and 0.45±0.051 (Tawi river) to 0.93±0.152 (ponds and wells of *kandi* area) during rainy season. The amount of nitrates in an aquatic medium is an interplay of meterological processes (precipitation, atmospheric solution and volatilization), geological processes (sedimentation, effluents and ground water movement) and biological processes (nitrogen fixation, denitrification, growth decay hydrophytes, pumping and removal of fish and weed) [21].

Dissolved oxygen regulates the metabolic activities of organism and thus governs the metabolism of the biological

community as a whole and also acts as an indicator of tropic status of the water. It is of prime importance in natural waters both as a regulator of biotic community and indicator of aquatic health. The concentration of dissolved oxygen (DO) ranged between 5.08±0.37 mg/l (ponds and wells of border belt) to 6.67±0.67 mg/l (ponds and wells of *kandi* area) during summer season and 4.55±0.14 mg/l (Tawi river) to 8.28±0.434 mg/l (ponds and wells of *kandi* area) during rainy season. Oxygen is generally reduced in water due to the respiration of biota, decomposition of organic matter, rise in temperature and oxygen demanding wastes and inorganic reluctant such as hydrogen sulphide, ammonia nitrites, ferrous iron etc. [22]. Minima in dissolved oxygen during summers may be due to high temperature which coincides with low oxygen content [23], increase in oxidation of organic matter during summer, increase in free carbon dioxide, increased metabolic rate of aquatic organisms leading to the consumption of bulk of dissolved oxygen from the aquatic medium as suggested by and increased day length and light intensity which probable after having acquired the optimal value start acting as a limiting factor for photosynthesis and hence decrease dissolved oxygen production.

Free carbon dioxide is the normal component of all natural waters. The amount of carbon dioxide in simple solution plus that in the form of H_2CO_3 (carbonic acid) is called the free carbon dioxide of aquatic medium. All the living autotrophs incorporate the free carbon dioxide by assimilation and this is the only source of carbon which is further utilized by organisms of different categories. The range of free carbon dioxide (FCO) recorded was 1.4±0.10 mg/l (ponds and wells of border belt) to 7.202±1.79 mg/l (post filtration) during summer season and 1.47±0.062 mg/l (Tawi river) to 9.53±1.163 mg/l (household) during rainy season. Biological oxidation of organic matter and dissolved carbon dioxide from air increases the level of carbon dioxide in water. Free carbon dioxide in water is mainly generated from the respiration of aquatic biota, decomposition of organic matter and infiltration through the soil [20].

Conclusion

From the present study of physico-chemical properties of water in district Jammu of J&K it was concluded that all the parameters were within the range of WHO and ISI standards except for the magnesium which was above the permissible limit.

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Table 1: Area of collection of samples

S. No.	Source of Samples		Place of Collection	No. Samples
1.	Tawi River (Pre Filtration)		1. Hari Ki Pouri Temple 2. Sidhra	32
2.	Filtration Plant		1. Sitlee Filtration Plant	32
3.	Households		1. Trikuta Nagar, Jammu 2. Gandhi Nagar, Jammu 3. City Chowk, Jammu.	24
4.	Ponds and Wells	Kandi belt	1. Samba 2. Channi	12
		Border belt	1. R. S. Pura 2. Arnia	12
	Total			112

Table 2: Drinking water standards used for comparison in the study

S. No.	Parameter	WHO Standards	ISI
1.	pH	7-8.5	6.5-8.5
2.	Ca^{2+} Hardness (mg/L)	100	75
3.	Mg^{2+} Hardness (mg/L)	150	30
4.	Chloride (mg/L)	250	250
5.	Nitrate	5	45
6.	Dissolved Oxygen	-	5.00

Table 3: Effect of Summer Season on Physico-Chemical Parameters (Mean ± S. E.) of Water

Source of water Samples	No. of Samples (n=112)	Temperature (^{0}C)	pH	Chloride (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Dissolve d O_2 (mg/l)	Free CO_2 (mg/l)
Tawi River (Pre Filtration)	16	38.1^a±0.423	7.9^a±0.044	20.7^a±1.41	20.7^a±1.41	30.3^b±1.87	0.3^a±0.03	0.2^a±0.02	5.1^b±0.21	4.5^c±0.14
Post Filtration	16	29.9^a±0.29	7.5^a±0.12	8.9^a±0.21	34^b±1.33	5.6^b±0.19	2.2^a±0.14	1.3^c±0.21	5.6^c±0.21	7.2^b±1.79
Household	12	20.2^a±0.59	7.1^a±0.12	20.3^b±2.39	29.7^c±2.39	5.4^a±0.22	2^b±0.29	1.9^c±0.26	5.82^b±0.09	4.6^b±1.44
Ponds & Wells Kandi area	6	29.3^b±0.8	6.6^b±0.26	25.2^b±6.26	27^c±3.14	30^a±1.19	8.2^b±4.09	2.3^b±0.16	6.7^b±0.67	4.33^a±0.77
Border belt	6	29.9±1.06	7.9±0.08	24.9±3.56	18.8±1.35	28.9±3.27	0.6^a±0.32	6.35^c±3.23	5^a±0.37	1.4^b±0.1

The values having different superscript differ significantly (P<0.05)

Table 4: Effect of Rainy Season on Physico-Chemical Parameters (Mean ± S. E.) of Water

Source of water Samples	No. of Samples (n=112)	Temperature (^{0}C)	pH	Chloride (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Dissolved O_2 (mg/l)	Free CO_2 (mg/l)
Tawi River (Pre Filtration)	16	29.1^{a}±0.276	7.9^{a}±0.039	25.2^{a}±2.48	23.3^{a}±1.13	29.8^{b}±1.34	0.3^{a}±0.05	0.2^{b}±0.02	4.5^{a}±0.14	1.4^{c}±0.06
Post Filtration	16	29.2^{a}±0.32	7.6^{a}±0.48	8.6^{b}±0.28	39.5^{a}±0.44	6^{c}±0.13	1.2^{a}±0.2	1.5^{b}±0.19	6.1^{c}±0.07	3.7^{b}±0.23
Household	12	29.4^{c}±0.32	7.3^{b}±0.7	13.2^{c}±3.03	43.2^{b}±3.29	12.6^{b}±1.41	3.9^{c}±1.26	2.8^{a}±0.29	6.4^{c}±0.15	9.5^{b}±1.16
Ponds & Wells Kandi area	6	28^{b}±0.58	6.8^{b}±0.24	30.6^{c}±4.43	28.8^{b}±3.08	27.7^{a}±1.73	6.1^{a}±1.52	2.7^{c}±0.29	8.28^{b}±0.43	3.7^{a}±0.75
Border belt	6	29^{a}±0.56	7.9^{a}±0.1	34.7^{b}±2.47	26.7^{a}±1.91	32^{c}±3.38	2.1^{b}±0.23	2.5^{a}±0.34	5.4^{b}±0.45	3.3^{b}±0.96

The values having different superscript differ significantly (P<0.05)

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