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Microbial examination of drinking water in district Jammu of J&K, India

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Abstract
A total of 112 water samples from Tawi river Pre-filtration, Post filtration water, household supplies, ponds and wells of kandi area and border belt in both summer and rainy season were collected and analysed for their microbial load. None of the samples complied with bacteriological standards for total Coliforms (TC), Faecal Coliforms (FC), Faecal *Streptococcus* (FS) and *Clostridium perfringens* (CP). During summer season, the values of TC, FC, FS, CP were highest (1359, 164, 664, 604 MPN/100ml respectively) in pre filtration Tawi river water and lowest (5.6, 3.5, 5.43 and 4.91 MPN/100ml respectively) in post filtration water. During rainy season also, the values of TC, FC, FS, CP were highest (2391, 227, 858 and 716 MPN/100ml respectively) in pre filtration Tawi river water and lowest (9.4, 6.2, 9.0 and 8.6 MPN/100ml respectively) in post filtration water. SPC/ml was highest for Tawi river (pre filtration) water (6.2×10^6) in rainy season and lowest for post filtration water (1.049×10^3) in summer season. Studies revealed cent percent faecal pollution of drinking water sources in the study area due to presence of coliform the indicator organisms. Highest level of faecal pollution was shown by Tawi River supplying inputs to the filtration plants. The water supply sources were unsatisfactory for drinking when compared with the WHO or BIS standards for coliform count. It was concluded that there is urgent need of public health advisory for public enlightenment by avoiding contaminated source of drinking water until corrective actions have been assured.

Keywords: Drinking water, Indicator organism, Jammu, MPN, SPC

Introduction
Water, as ubiquitous on earth as is imperative for life, seems to be losing its age old natural purity. Even though water is abundant, the amount of potable fresh water available is a tiny fraction of the total amount of water in the world. Rivers are the most important water resource. Unfortunately, the worldwide rivers are being polluted by indiscriminate disposable of sewage, industrial waste and plethora of human activities, which affects its microbiological quality, making it unsafe for consumption [1]. There is an extensive literature stressing deterioration of water quality due to increased industrial activities [2, 3], risk of water-borne diseases due to contamination and the potential health hazards that may result from drinking contaminated water by the industries [4]. Deteriorated water quality poses greater risk to both human and animal life which incurs regular studies should be conducted for water quality. The ranking of India is far low (120th out of 122 nations) as far as the quantity and quality of freshwater is considered, waste water treatment facilities as well as legal issues such as the application of pollution regulations and our position is below the neighboring countries like Bangladesh (40th), Sri Lanka (64th), China (84th) and Pakistan (80th) [5]. 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. 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. As in most parts 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 [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 aluminum foil. The samples were collected following the standard procedure of American Public Health Association [7]. The samples were processed for estimation of most probable number of index bacteria using standard procedure for Multiple Tube Fermentation Technique [8]. Fifteen tube dilution procedure was followed for enumeration of most probable number of coliforms, faecal *Streptococci* and *Clostridium perfringens* using double and single strength bromo-cresol purple MacConkey's bile broth, Hanny & Norton's sodium azide broth and Litmus milk respectively (Hi Media Ltd., Mumbai, India). The serially diluted samples were processed for determination of SPC employing surface spread plate technique on plate count agar [9]. Isolation and identification of the organisms was carried out as per the method described by Cowan and Steel [10].

Discussion

The study was conducted to evaluate bacteriological quality of the drinking water collected at different places and seasons of district Jammu of J&K (Table 1). was assessed by measurement of the SPC and by quantification of total coliforms, *E. coli*, faecal Streptococcus and Clostridium perfringens spores. The results revealed the presence of coliforms, faecal coliforms, faecal *Streptococcus* and *Clostridium perfringens* in all the samples from Tawi River supplying inputs to the filtration plant. The study recorded that as compared to WHO standards for drinking water and none of the samples obtained from river water was fit for consumption. Similar results were reported by in stream water supplying inputs to various filtration plants of Srinagar city [11, 12]. The surface water is generally exposed to dust, sewage and other decomposing matter resulting in increasing the bacterial load of these indicator organisms in surface water.

The faecal coliform index for the Tawi River was recorded to be 164.76±8.23/100ml in summer season and 227.39±8.141/100ml in rainy season. The results obtained are however, in agreement with the findings of Lyautey [13] who reported *E. coli* densities to range from undertectable to 1.64 x 10^5 CFU/100ml from surface waters from multiple watersheds within the South Nation River basin in eastern Ontario, Canada. Chandra [14] also reported higher values of *E. coli* $1.57x10^4$, $1.6x10^4$, $1.37x10^4$ per 100ml during summer, monsoon, and winter respectively in Gola River in Uttaranchal, India. These reported mean values were greater than the international recommended guidelines for drinking water quality. The faecal *Streptococcus* and *Clostridium perfringens* index for the Tawi river were 664.09±51.368 and 604.29±57.514 respectively in summer season and 858.08±34.055 and 716.03±38.36 respectively in rainy season which is quite higher. The surface water sources of Cameroon had faecal Streptococcus counts ($2.1x10^2$-$2.3x10^2$ CFU/100ml) [15]. The numbers of faecal Streptococci in treatment plant intakes on the main stream of Nile River ranged from 8 to 250 MPN/100ml [16]. Tawi river presented higher loads of these bacteria compared to the other sources which could be due to higher contamination rates in it. *Clostridium perfringens* are present in the faeces of all warm blooded animals as well as in sewage. They are stable in environmental waters and show greater resistance to the disinfection processes than most pathogens. Their presence in water indicates the faccal contamination of water having occurred remotely.

The SPC/ml of Tawi river (Pre filtration) was $4.8x10^5$. The findings corroborate similar earlier reports. Shittu reported TVC of the river water was $2.01x10^7$ CFU/ml [17]. Chandra *et al.,* (2006) reported that the SPC of the Gola river, Uttarakhand was $1.6x10^4$, $1.68x10^4$ and $1.67x10^4$ CFU/100ml during summer, monsoon and winter respectively. The total bacterial density of River Ganges to be 1.90-$22.26x10^3$.100ml [18]. The higher total heterotrophic count in our study probably indicative of the presence of high organic and dissolved salts in the water. It may be due to the increase in human and livestock wastes resulting in faecal contamination of water suggestive of poor, unhygienic status of the input water. Further, the study revealed that the level of contamination of most of post filtration water samples was lesser compared to the other sources. The coliform and faecal coliform index for post filtration water was 5.6±0.494 and 3.52±0.296 per 100 ml respectively in summer season and 9.387±0.443 and 6.175±0.481 respectively in rainy season. The faecal *Streptococcus* and *Clostridium perfringens* index was 5.43±0.331 and 4.91±0.353 per 100ml respectively in summer season and 9.037±0.469 and 8.63±0.526 per 100ml respectively in rainy season. The number of aerobic bacteria was higher than the recommended permissible drinking water limits for TVC of less 100 CFU/ml.

Overall the MPN of the faecal *Streptococcus* (31.86±1.329) was higher as compared to coliforms (8.32±0.597) or *Clostridium perfringens* (8.22±0.62) in summer season (Table 2) and faecal Streptococcus (49.975±6.096) was higher as compared to coliforms (15.6±0.939) or *Clostridium perfringens* (9.36±2.89) in rainy season (Table 3) in household water. Similar findings were reported by Rather *et al*. (2009) who found MPN of faecal *Streptococcus* as 49.84±19.76 per 100ml in the household water supply of the Srinagar City. The household water showed the increase the average most probable number of faecal *Streptococcus* than the water immediately post filtration. It could probably be due to regrowth of the organisms in the distribution system which is determined by temperature, availability of nutrients and lack of residual disinfectant. The MPN of the coliforms, faecal coliforms, faecal *Streptococcus* and *Clostridium perfringens* was 33.21±2.253, 12.96±0.593, 30±1.109 and 11.06±0.823 respectively in summer season and 44.1±3.483, 27.63±4.11, 44.1±3.483 and 20.45±2.226 respectively in rainy season in the ponds and wells of kandi area. The findings are in agreement with Geen who studied 125 tubewells of Bangladesh and detected E. coli at levels exceeding 1MPN/100ml in 19-64 percent of tube-well [19]. In the study faecal streptococcus were detected more often than thermo tolerant coliforms (*E. coli*) while it may be due to higher numbers in faecal material than other bacteria besides being more resilient in non-enteric environments. Similar reason for these bacteria being at a larger concentration in groundwater samples than thermotolerant coliforms [20].

In the present investigation SPC of ponds and wells of kandi area was $2.16x10^5$ and $4.26x10^5$ in summer and rainy season respectively (Table 4). Similar findings were also reported by Adeyemo who reported highest mean bacterial count of well water in Nigeria as $15.4x10^4$ CFU/ml [21]. The lower SPC counts from well water compared to the Tawi river water may be attributed to the nutrient deficient under-ground aquatic environments. Ponds and wells of border belt showed SPC/ml count of $3.46x10^6$ and $5.36x10^5$ respectively in summer and rainy season. These findings also corroborated with who reported SPC/ml to be 2.13x104 CFU/ml in ground water of

Kerala [22]. The recorded estimate of SPC for filling station was lowest among the untreated water. The ground water sources are often used without any treatment, except physicochemical ones to reduce hardness or eliminate off-flavours and odors.

Conclusion

From the results it was concluded that most of the water sources under study in and around Jammu were showing faecal pollution due to the pollution of indicator organisms. Highest level of faecal pollution was shown by Tawi River supplying inputs to the filtration plants. The water supply sources were unsatisfactory for drinking when compared with the WHO, BIS and/or ICMR standards for coliform count. Most of the samples from inputs to filtration plant, post filtration water, household supply, ponds and wells of *kandi* area and border belt did not conform to the WHO standards for faecal coliform count. The microbial contamination of drinking water is a major issue worldwide thus surging an urgent need of public enlightenment and awareness.

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Tables

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: MPN of Indicator Organisms (Mean ± S. E.) in Different Drinking Water Sources (Summer Season)

Source of water Samples	No. of Samples (n=56)	MPN (Mean ± SE) per 100 ml water			
		Total Coliforms	Faecal Coliforms	*Faecal Streptococcus*	*Clostridium Perfringens*
Tawi River (Pre filtration)	16	1359.6^{b}±38.086	164.76^{a}±8.23	664.09^{a}±51.368	604.29^{a}±57.514
Post Filtration	16	5.60^{a}±0.494	3.52^{a}±0.296	5.43^{a}±0.331	4.91^{a}±0.353
Household	12	8.32^{a}±0.597	4.36^{a}±0.47	31.86^{a}±1.329	8.22^{a}±0.620
Ponds & Wells Kandi area	6	33.21^{a}±2.253	12.96^{a}±0.593	30.00^{a}±1.109	11.06^{a}±0.823
Border belt	6	36.26^{a}±2.105	11.95^{a}±0.881	29.82^{a}±1.35	13.15^{a}±0.506

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

Table 3: MPN of indicator organisms (Mean ± S. E.) in different drinking water sources (Rainy Season)

Source of water Samples	No. of Samples (n = 56)	MPN per 100 ml water			
		Total Coliforms	Faecal Coliforms	*Faecal Streptococcus*	*Clostridium Perfringens*
Tawi River supplying inputs to Filtration Plants	16	2391.1^{b}±164.78	227.39^{b}±8.141	858.08^{b} ±34.055	716.03^{b}±38.36
Post Filtration	16	9.387^{a}± 0.443	6.175^{a}±0.481	9.037^{a} ±0.469	8.63^{a}±0.526
Household	12	15.6^{a}±0.939	9.658^{a}±0.581	49.975^{a} ±6.096	9.36^{a}±2.89
Ponds & Wells Kandi area	6	44.1^{a}±3.483	27.63^{a}±4.111	44.1^{a} ±3.483	20.45^{a}±2.226
Border belt	6	62.916^{a}±9.463	21.416^{a}±1.929	50.2^{a}±3.643	27.708^{a}±4.2

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

Table 4: Standard Plate Count of water from different sources

Source	No of Samples	Colony Forming Units (CFU) per ml	
		Summer Season	Rainy Season
Tawi River (Pre filtration)	16 each	4.8×10^{5}	6.2×10^{6}
Post Filtration Water	16 each	1.049×10^{3}	3.46×10^{5}
Household Supply	12 each	2.46×10^{4}	5.34×10^{5}
Kandi Area	6 each	2.16×10^{5}	4.26×10^{5}
Border Belt	6 each	3.46×10^{6}	5.36×10^{5}

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