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CHEMISTRY OF TORRENT WATER IN AZAD JAMMU & KASHMIR, PAKISTAN

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A field study was conducted to estimate the seasonal and regional variations in physicochemical characteristics of water of the hill torrents located in Azad Jammu & Kashmir where torrent water is used for drinking purposes. Ten torrents within the populated areas were selected and analyzed for about 30 parameters, including four major and seven minor metal contents. The monitoring was carried out for summer, autumn and winter during 2004 – 2005. Total dissolved solids (TDS) were observed within 145 – 561 µg/ml and 50 % of the torrent water crossed the limit of 500 µg/ml for TDS. For lead 80 %, for cadmium 90 % and for Kjeldahl nitrogen 40 % of studied torrents indicated higher values than the permissible limits of WHO for drinking water. No significant changes were observed in torrent water quality during different seasons.

Keywords: Torrent water, Kjeldahl nitrogen, Siwalik rocks, Total dissolved solids (TDS)

1. Introduction

Water is the basic necessity of life and is rarely available in the towns located at hill tops in Pakistan. Several towns and villages in the mountainous regions of Azad Jammu & Kashmir have shortage of water throughout the year. The torrents are abundant in hilly areas. The original source of such torrents, in most of the areas, is unconfined aquifers where the flow of water is under gravity. Ground water carries a lot of soluble chemical compounds while passing through different geological formations. Human activities in the recharge area also bring about some changes in the ground water, which may have complications for consumers. Favorable geological characteristics are responsible for a number of torrents within Azad Jammu & Kashmir. The saddle-shaped ridges, on which most of the towns are developed, form the recharge area of these torrents [1].

The domestic sewage of the towns is disposed of untreated through landfills and unlined open drains. In haphazardly growing towns such as Authmuqam, Palandri, Trarkhal, Fatehpur, Abaspur, Dhirkot, Charoi, Hattian Bala, Haveli and cities like Muzaffarabad, Rawlakot and Kotli, the possibility of surface water pollution can not be ruled out. The depth of the soil column in the town areas may not be sufficient to provide adequate treatment to polluted surface water and the contaminants present in it, therefore, may percolate to subsoil water. The polluted subsoil water can emanate with torrent discharge and this may bring some changes in chemistry and microbiology of the water of these torrents. Originating from the shallow water table, such torrents are more susceptible to contamination.

The present work examines the physico-chemical characteristics of the water of 10 perennial torrents within Azad Jammu & Kashmir to assess the status and regional and seasonal changes in the water quality.

2. Area and Geology

The state of Azad Jammu & Kashmir lies between longitude 73° – 75° and latitude 33° – 36° and comprises of 13297 km^2 area. It is divided into two divisions (Muzaffarabad and Mirpur) and eight districts (Neelum, Muzaffarabad, Bagh, Poonch, Sudhnoti, Kotli, Mirpur and Bhimber).

Each of districts is further divided into two to three subdivisions. The total population according to 1998 census is 2.8 million, with 87.5 % living in rural and 12.5 % in urban areas. The average population density is 246 persons per km^2.

It extends from the plains of Bhimber at

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northern edge of the Punjab through the outlying foothills of Himalayas, to the mountains in the north at 6325 meters above sea level. The elevation ranges from 360 m in the south to 6325 m in the north. The annual rainfall is of 1500 mm. It is a land strip in the shape of crescent moon, 400 km in the length with width varying from 15 - 60 km. The snow line in the winter is around 1200 m above sea level, while in the summer it rises to 3300 m [2]**.**

Azad Jammu & Kashmir consists of Siwalik rocks mostly in the western part of the Poonch district alongwith the eastern bank of the Jhelum River. These rocks crop out between Kohala and Azad Pattan. The eastern contact runs in an irregular fashion from Hajeera through Rawlakot to Dhirkot. Wada (1928) divided the Siwaliks of Kashmir into Lower Palandri, Middle Mang and Upper Sand Rock Stage. It is of concern that both Palandri and Mang are located in Poonch District. The rocks between Titwal and Loat, comprise of psammitic-pelitic sequence, resembling the tanol formation. The rocks found in the vicinity of Authmuqam have also been considered as a part of psammite pelite sequence. Kotli area indicated precambrian rock formation [3, 4] have also shown a provenance for Kotli Middle Siwaliks similar to the Lower Siwaliks of Poonch.

3. Methodology

The study involves preliminary survey, monitoring of torrents and testing of water to ascertain the physico-chemical parameters. The objective of the field survey was to locate and select the torrents for the study. The torrents can be considered as the representative of underground water [5]. Ten perennial torrents having sufficient discharge throughout the year were selected for the study (Table 1)**.** The torrents selected district wise were one from Bhimber two from Kotli, one from Sudhnoti, two from Bagh and four from Muzaffarabad. The samples were collected three times during the months of June, October and February 2004-2005. Measurement of each parameter was obtained through field and laboratory analysis of samples. Well-mixed sample was transferred to a clean 2.5 L plastic bottle after rinsing several times with the sample. The temperature of water and air 1 m above the surface of water was noted. The dissolved oxygen (DO) in the samples was determined by Wrinkler method [6]. Chemical oxygen demand (COD) was estimated by micro-dichromate oxidation method [7]. Hardness, chloride and alkalinity were determined by titration with standard EDTA, silver nitrate and hydrochloric acid solution. Conductivity, salinity and total dissolved solids (TDS) were evaluated with Orion 115 conductivity meter. The pH was recorded with Orion 420 A pH meter. Kjeldahl nitrogen was determined by using standard procedure [6]. Orthophosphate, nitrate and nitrite were determined by spectrophotometry. Orthophosphate was determined by reducing phosphomolybdic acid formed with ascorbic acid to molybdenum blue. Total phosphate was estimated by persulphate acid hydrolysis, followed by determination as for orthophosphate. Nitrate was determined after derivatization with brucine sulphate. Nitrite was estimated using N-naphthyl ethylenediamine as derivatizing reagent as reported [6]**.** Sulphate was determined by turbidimetery as $BaSO_4$ using Hitachi 220 spectrophotometer. The metal ions Na, K, Ca, Mg, Fe, Pb, Cu, Zn, Ni, Cd, and Co were determined with Varian Spectra AA-20 atomic absorption spectrometer with standard burner head and air acetylene flame at the conditions recommended by the manufacturer. The analysis was carried out in triplicate with integration time 3 second and delay time 3 second. Na, K, Ca and Mg were determined after appropriate dilution. Sample (250 ml) containing nitric acid (1 ml) was heated gently at 90-95 ^oC and was concentrated to about 15 -20 ml. The solution was transferred to volumetric flask and final volume was adjusted to 25 ml. The solution was analyzed for the contents of Fe, Pb, Cu, Zn, Ni, Cd, and Co by air acetylene flame atomic absorption spectrometer.

4. Results and Discussion

The map of Azad Jammu & Kashmir together with the locations of the torrents is indicated in Fig. 1. The average results (n=3) of physico-chemical characteristics of torrent water are summarized in Table 1 and reveal varying nature of the torrent water. The difference in the quality of water may be due to some difference in the bed, different rechargeable zones and human activity [8]. The torrents T_1, T_2, T_7, T_9, and T_{10} are located in the area of relatively thin population density; the torrents T_3 and T_8 are located within medium intensity of population. The torrents T_4, T_5 and T_6 are located in the central area of Muzaffarabad city with high population density. All the selected torrents are perennial in nature and show a flow of water throughout the year. However, during the monsoon, the flow rate is observed to be enhanced whereas in long draughts the flow rate comes down. Some of the torrents are being

Table 1. Mean values of physicochemical parameters of torrents water of Azad Jammu and Kashmir.

Parameters	T_1 ±SD (n=3)	T_2 ±SD (n=3)	T_3 ±SD(n=3)	T_4 ±SD (n=3)	T_5 ±SD (n=3)	T_6 ±SD (n=3)	T_7 ±SD (n=3)	T_8 ±SD (n=3)	T_9 ±SD (n=3)	T_{10} ±SD (n=3)
pH (25 ^oC)	6.85± 0.28	7.26±0.50	6.8±0.44	6.69±0.18	6.83±0.13	7.36±0.41	7.91±0.3	7.13±0.03	7.67±0.43	7.71±0.26
E.C µS/cm	877±23.9	891±15.58	572±11.72	853±64.34	864±18.23	583±24.27	277±28.21	818±8.00	226±7.00	332±5.00
TDS µg/ml	561±15.3	570±9.81	366±7.37	545±41.19	553±13.54	372±15.53	189±7.07	523±5.50	145±4.51	213±3.21
Salinity g/L	0.4±0.0	0.4±0.00	0.3±0.00	0.4±0.00	0.4±0.00	0.3±0.00	0.15±0.07	0.4±0.00	0.2±0.00	0.2±0.00
HCO_3 µg/ml	410±39.2	309±29.10	324±30.00	259±77.4	318±42.23	285±72.11	205±6.36	410±6.24	250±11.00	310±5.57
Hardness µg/ml	402±15.5	342 ±41.2	281±30.65	366±170.18	382±44.32	324±57.17	261±23.33	380±5.57	240±5.00	180±7.64
Chloride µg/ml	22.4±2.2	52.8±8.72	28.03±7.66	56.3±15.58	70.6±14.52	33.8±6.19	63.8±5.03	99.3±10.79	46.1±3.05	49. ±1.64
Sulphate µg/ml	85.4±1.5	39.2±9.8	19.71±7.17	49.6±13.97	55.1±11.21	62.2±10.39	14.1±3.18	34.0±3.60	18.9±1.02	17.6±3.40
Nitrite-N µg/ml	0.006±0.0	0.052±0.0	0.004±0.01	0.038±0.00	0.066±0.01	0.021±0.01	0.005±0.00	0.05±0.03	BDL	0.002±0.00
Nitrate-N µg/ml	2.76±0.6	3.12±1.34	8.24±1.81	11.21±0.26	12.21±0.32	10.8±0.55	2.86±0.42	3.92±0.39	2.35±0.88	1.20±0.32
K-N µg/ml	0.15±0.05	0.36±0.06	1.93±0.23	6.11±0.59	3.89±0.71	2.41±0.20	0.603±0.00	0.30±0.10	0.88±0.10	0.55±0.03
O - PO_4 µg/ml	0.26±0.03	0.28±0.04	0.22±0.05	0.26±0.04	0.24±0.04	0.23±0.10	0.100±0.00	0.55±0.00	0.52±0.02	0.36±0.02
T.PO_4 µg/ml	0.28±0.04	0.31±0.04	0.43±0.03	0.29±0.043	0.26±0.03	0.26±0.03	0.02±0.00	0.58±0.06	0.61±0.05	0.40±0.01
DO µg/ml	5.82±2.03	5.37±2.04	5.82±0.81	5.27±0.51	6.82±0.67	5.85±1.01	6.41±0.13	3.79±0.44	6.9±2.40	8.60±1.10
BOD µg/ml	0.93±0.34	8.23±0.81	6.49±2.78	18.32±3.12	22.01±3.98	16.32±0.82	2.48±0.73	4.84±0.71	4.14±0.76	4.21±0.29
COD µg/ml	29.27±21.9	24.96±4.0	19.4±2.88	56.23±6.5	59.12±7.64	51.36±2.03	12.00±3.32	16.2±2.92	18.3±1.55	15.2±2.8
Na µg/ml	62.39±29.6	32.0±6.4	6.81±0.847	21.95±6.83	16.28±2.31	20.04±1.04	8.88±1.36	32.26±4.69	6.57±0.91	3.14±0.66
K µg/ml	9.54±6.55	7.2±2.15	3.42±0.325	6.36±2.02	7.05±1.25	20.83±2.10	2.74±0.98	2.21±0.78	3.65±0.45	2.57±0.31
Ca µg/ml	103.94±29.8	130.3±18.6	112.7±26.2	136.7±31.62	176.1±9.32	76.21±4.12	50.35±4.69	92.19±9.11	48.81±2.19	44.80±1.33
Mg µg/ml	70.38±31.20	59.17±13.5	20.1±6.179	43.51±13.25	41.16±3.21	66.72±4.68	32.95±0. 97	22.97±2.65	10.68±1.18	6.84±0.16
Fe µg/ml	0.014±0.01	0.011±0.00	0.023±0.00	0.017±0.01	0.021±0.00	0.019±0.00	0.026±0.00	0.03±0.00	0.045±0.02	0.04±0.01
Cu µg/ml	0.002±0.00	BDL	BDL	0.001±0.01	0.02±0.000	0.005±0.00	0.012±0.00	0.01±0.00	0.009±0.00	0.05±0.02
Zn µg/ml	0.012±0.004	0.025±0.01	0.057±0.00	0.041±0.01	0.044±0.00	0.026±0.00	0.031±0.01	0.005±0.00	0.006±0.00	0.01±0.00
Ni µg/ml	0.018±0.005	0.030±0.01	0.02±0.01	0.024±0.01	0.029±0.00	0.031±0.01	0.039±0.00	0.024±0.00	0.031±0.00	0.05±0.01
Pb µg/ml	0.037±0.01	0.056±0.00	0.071±0.00	0.064±0.00	0.038±0.00	0.064±0.00	0.029±0.01	0.015±0.00	0.011±0.00	0.01±0.00
Cd µg/ml	0.004±0.003	0.019±0.00	0.036±0.00	0.027±0.00	0.042±0.01	0.035±0.00	0.079±0.02	0.003±0.00	0.004±0.00	0.02±0.01
Co µg/ml	0.040±0.023	0.064±0.02	0.072±0.03	0.046±0.02	0.06±0.01	0.033±0.00	0.274±0.08	0.26±0.00	0.024±0.00	0.04±0.01

BDL = Below Detection Limit

K-N = Kjeldahl Nitrogen

O- PO_4 = Orthophosphate

T.PO_4 = Total phosphate

T 1. Hamga Torrent, Subdivision Samahni District Bhimber.

T 2. Riverside Bridge Torrent, Subdivision & District Kotli.

T 3. Tararkhal Torrent near Petrol Pump, Subdivision Tararkha, District Sudhnoti.

T 4. Domel Torrent, Muzaffarabad City.

T 5. City Torrent near Palace Hotel, Muzaffarabad City.

T 6. Chela Torrent near New Campus Azad Jammu & Kashmir University, Muzaffarabad.

T 7. Hattian Bala Torrent near Mahajar Camp, Subdivision Hattian Bala, District, Muzaffarabad.

T 8. Doongi Torrent, Subdivision & District Kotli.

T 9. Bann Deegwar Torrent Subdivision Haveli, District Bagh.

T 10. Mehmood Gali Torrent near Rawalpindi Road, Subdivision Haveli, District Bagh.

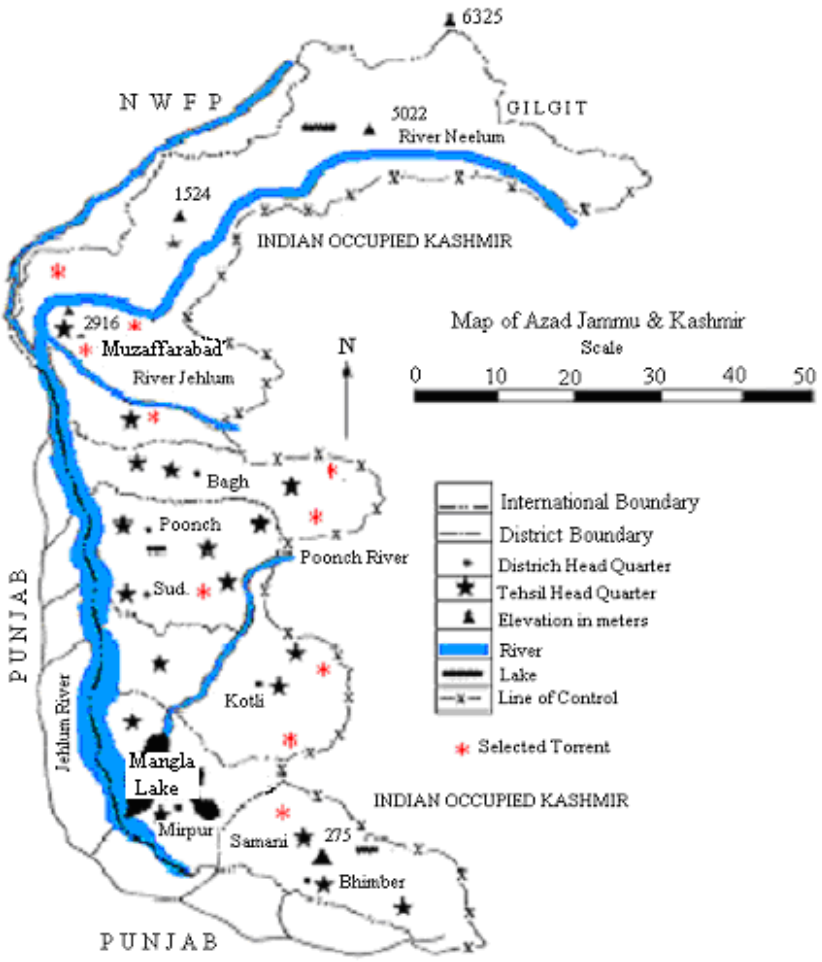

Figure 1. Map of Azad Jammu & Kashmir with locations of selected torrents

used as major source for water supply schemes to benefit several villages with fresh and clean water.

4.1. pH of torrent water

The pH of the torrents was found between 6.69 and 7.91. The springs T_1, T_3, T_4, and T_5, indicated pH below 7 may be because of leaching of acidic water by the decomposition of pine litters over the ground surface [9]. However, the pH of the torrents T_2, T_6, T_7, T_8, T_9 and T_{10} was found slightly towards basic side. Significant change was not observed in the water pH during different seasons and it was found well within the permissible limits of 6.5- 8.5 of WHO [10].

4.2. Electrical conductivity and total dissolved solids

A significant variation in the values of electrical conductivity (EC) and total dissolved solids (TDS) among the torrents was observed. EC and TDS varied within the range 226 - 891 µS/cm and 145 - 570 µg/ml respectively. A significant difference was not observed in EC and TDS with variation in seasons for all the torrents investigated. The torrents T_1, T_2, T_4, T_5, and T_8 showed slightly higher values of EC and TDS than the permissible limits.

Torrents T_4, T_5 and T_8 are located within high and medium population density and may be affected by human activity within rechargeable locations.

4.3. Dissolved Oxygen

The dissolved oxygen (DO) expressed the variation within 3.79 – 8.60 µg/ml. Low oxygen contents were observed from torrents with little storage capacity and short stay time in the open atmosphere as the water was sampled just after oozing out from the mountains. Hence torrent water got a little chance to dissolve the oxygen.

The torrents with large storage capacity indicated higher DO content. A significant seasonal variation in the values of DO was observed, ranging from 3.79 µg/ml to 8.60 µg/ml, during the investigating period. The logical association with the seasons indicates the temperature dependent trend of DO (Fig. 2). The presence of DO is required to prevent odor and is suitable for use by aquatic plants and other life forms.

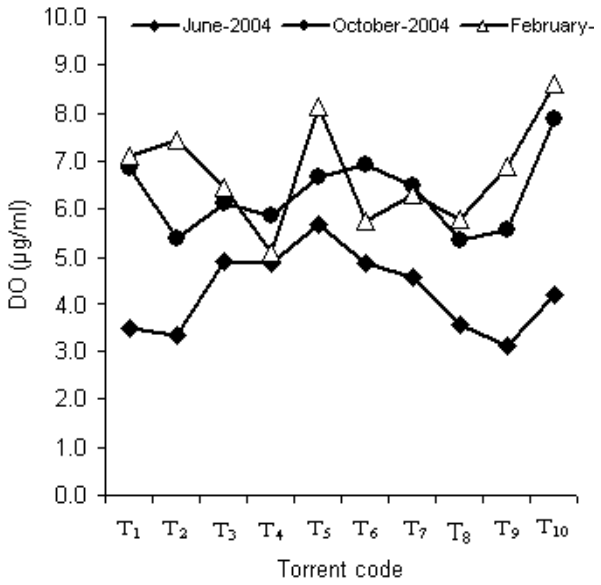

Figure 2. Seasonal variation in the DO contents in the torrent water.

4.4. Total chlorides

The chloride contents of torrent water indicated variation within 22.4 – 99.3 µg/ml. The chloride contents indicated concentration well within the WHO drinking water standards, but the torrents T_4, T_5 and T_8 bearing high population density showed comparatively higher values than others. There is a little variation in chloride concentrations with seasons and indicate high values in autumn, may be because of less dilution in dry season.

4.5. Sulphate

Sulphates were found present in all the torrents under investigation. The concentrations varied within 14.1 – 85.4 µg/ml. Seasonal variation indicated parallel results as for chloride with higher values observed in autumn**.** All the results of sulphate were found within standard safe limits WHO.

4.6. Nitrates, nitrites and kjeldahl nitrogen

Kjeldahl nitrogen, nitrite and nitrate are different forms of nitrogen and may be present in the water due to the decomposition of proteinous compounds, which enter in wastewater [11]. Presence of nitrogen of mineral origin is rare in natural waters and presence of nitrogen compounds like Kjeldahl nitrogen, nitrite and nitrate in water indicate pollution with domestic wastewater. Nitrate nitrogen is highest oxidized form of nitrogen in water and WHO standards prescribe 10 µg/ml as maximum permissible nitrate in higher concentration of potable water [10]**.** The torrents T_4, T_5 and T_6 located in the congested areas of Muzaffarabad city, crossed the safe limit (10 µg/ml) may be because of seeping down of domestic waste, animal debris and unlined open drain water.

Nitrite is more toxic and Kjeldahl nitrogen indicates the recent pollution from wastewater. Maximum permissible limit of WHO for both is 1.0 µg / ml. The nitrite showed values within standard limits but the Kjeldahl nitrogen crossed the permissible limit for torrents T_3, T_4, T_5, and T_6 within 1.93 – 6.11 mg/L. A significant seasonal variation in the values of nitrate was not observed, during the investigating period (Fig 3).

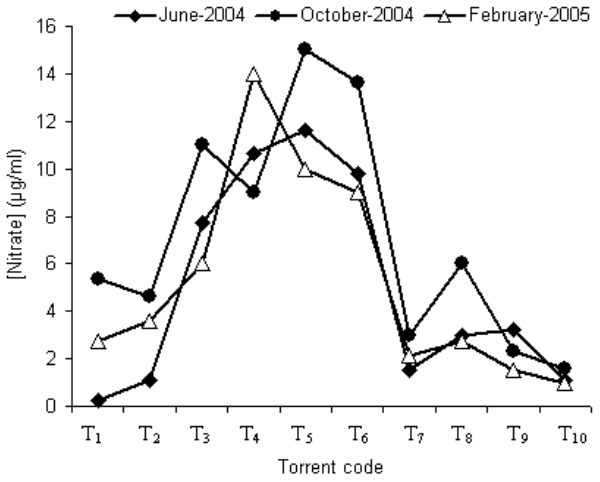

Figure 3. Sessional variation in the nitrate contents in the torrent water.

4.7. Phosphorous

The phosphorous contents (orthophosphate and acid hydrolysable phosphate) in water may be due to the geological reasons and human activity, particularly from the detergents. However, the results of analysis for the orthophosphate and acid

hydrolysable phosphate obtained from the torrents were found within permissible limits (Table 1). Orthophosphate varied 0.1 – 0.55 µg/ml and acid hydrolysable phosphate 0.02 – 0.61µg / ml.

4.8. Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD)

COD and BOD are considered standard parameters to estimate contamination in the wastewater. The torrents T_4, T_5 and T_6, located under high population pressure showed higher values of COD 56.23 µg/ml, 59.12 µg/ml and 51.36 µg/ml respectively (Table 1)**.** BOD values (18.32, 22.01 & 16.32 µg/ml) were also investigated slightly towards higher side for the same torrents. Keeping in view the physicochemical investigations, anthropogenic contribution to enhance the pollution content can not be ruled out.

A significant seasonal variation in the values of COD was not observed, during the investigating period (Fig 4)**.**

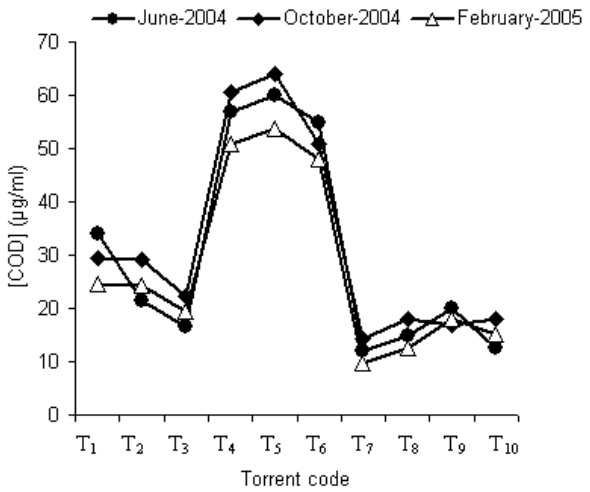

Figure 4. Sessional variation in the COD contents in the torrent water.

4.9. Metal ion contents

The total eleven metal contents (Na, K, Ca, Mg, Cu, Ni, Zn, Fe, Pb, Cd, Co) were subjected to analysis for all the ten selected torrents. The concentration of Na, K, Ca, and Mg varied considerably within the torrents and Ca was dominant throughout**,** followed by in the decreasing sequence Na > Mg > K. The concentration ranges for all the springs investigated varied within the limits Ca 44.8 – 176.1 µg/ml, Na 3.14 – 62.39 µg/ml, Mg 6.84 – 70.38 µg/ml, and K 2.21 – 20.83 µg/ml (Table 1). A clear pattern for the variation of Ca, Mg, Na and K with population was not observed. It was observed that the concentration of Na, K, Ca, and Mg was higher in autumn as compared to summer**.** It may be due to extensive rain in summer which resulted in the dilution of the salt contents within the catchment area of torrents.

The metal contents of Cu, Ni, Zn, Fe, Pb, Cd, and Co were determined. Most of the results are within the permissible limits of WHO for metal ions. However, the lead contents observed crossed the permissible limit for torrents T_1 to T_8 and cadmium also crossed the safe limit (Table 2) for torrents except T_8. Ashraf and Chaudary observed lead contents in the bed rock within the state of Azad Jammu & Kashmir [3]. It may be because of geological nature of the catchment area.

Table 2. WHO guideline values for major and trace metal ions for drinking water.

Element	WHO Guidelines (µg/ml)
Na	200
K	NGV
Ca	NGV
Mg	150
Fe	0.3
Cu	1.0
Zn	3.0
Ni	NGV
Cd	0.003
Pb	0.01
Co	NGV

NGV = No guideline value.

The metal ions were observed within the following limits: Fe 0.011 – 0.045 µg / ml, Cu 0.001 – 0.05 µg/ml, Zn 0.005 – 0.057 µg/ml, Ni 0.02 – 0.05 µg/ml, Co 0.027 - 0.033 µg/ml, Pb 0.001 – 0.071 µg/ml and Cd 0.003 – 0.079 µg/ml (Table 1)**.** A significant difference was not observed in the metal contents with seasons.

4.10. Sodium Adsorption Ratio (SAR):

Sodium adsorption ratio was calculated and the results obtained were within 0.205-2.67 and suggest that the water of the torrents is suitable for agricultural purposes [12]**.**

5. Conclusion

The torrent water chemistry shows trends indicating influence of base flow through rocks and possibility of percolation of polluted surface water. Seasonal variations in different parameter values for each torrent are marginal except DO which shows significant change in association with seasons. Population density has some effect on water quality of torrent water. Higher concentrations of lead, cadmium, nitrate and Kjeldahl nitrogen than permissible limits need some remedial measures for the use of torrent water for drinking purposes. The relation of Ca with carbonate suggests the presence of $CaCO_3$ rock in the catchment areas. The higher concentration of lead and cadmium in torrent waters reflects the geological nature of the catchment area.

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