Annals of Plant and Soil Research 23(1): 82-87 (2021)
https://doi.org/10.47815/apsr.2021.10034

Seasonal assessment of suface and ground water in Himalayan footh hill, Uttarakhand

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Received: September, 2020; Revised accepted: October, 2020

ABSTRACT

An investigation was carried out to assess the quality of water in Himalayan foot hill, Uttarakhand. The surface and ground water samples were collected during summer, monsoon and winter season from four sites. These water samples were analysed for their physico-chemical properties and heavy metals. The results revealed that the pH, EC, TDS and bicarbonate ranged from 7.2 to 7.7, 350.7 to 563.2 µScm^{-1}, 385.7 to 906.7 ppm and 146.7 to 186.3 ppm, respectively in surface water, irrespective for season. The corresponding values for these parameters in ground water ranged from 7.1 to 7.3, 335.5 to 364.0 µScm^{-1}, 316.7 to 610.0 ppm and 144.5 to 164.2 ppm. The concentrations of Na, K, Ca and Mg varied from 4.4 to 12.6 ppm, 1.8 to 18.0 ppm, 25.5 to 42.9 ppm and 16.6 to 32.0 ppm, respectively in surface water whereas the concentrations of these elements in ground water ranged from 4.6 to 6.8 ppm, 1.5 to 7.7 ppm, 19.5 to 35.6 ppm and 16.0 to 28.8 ppm, respectively. All the heavy metals were in safe limit in both sources of waters. In general, the concentrations of these water quality parameters were relatively higher during summer and lower in monsoon. On the basis of water quality index, the water samples collected from site-I and site-IV were rated as good to Excellent, whereas water samples of site-II and site-III were rated as poor to good in surface water. However, ground water at all the sites have been rated as good to excellent for the sustainable development.

Keywords: Groundwater, surface water, quality, Himalayan foot hill, Uttarakhand

INTRODUCTION

The groundwater quality in an area is defined by its physical and chemical parameters which in turn are affected by climatic conditions, geological formations, and anthropogenic activities Therefore, assessment of groundwater quality is important to ensure its safe use (Kumar and Singh, 2020). Surface water resources in the Dehradun region, are rapidly shrinking due to their excessive use and the changes in the monsoon pattern, which is mounting a tremendous amount of pressure on the groundwater resources. Water pollution caused by heavy metals is a continuously emerging problem associated with urbo-industrialized countries. The survivability of both plants and animals has constantly being affected since the advent of such developmental activities as mining and smelting, sewage, warfare, metallurgical industries, and tanning.Trace metals are amongst the most common pollutants that have severely affected the aquatic environment (Giri and Singh, 2014; Mahato *et al.,* 2017). Both natural and anthropogenic processes are responsible for their discharge into the aquatic ecosystems. Trace metals may introduce serious ecological threat if these enter food chain through bioaccumulation. Water Quality Index (WQI) is a tool for assessing the suitability of water quality. It is also useful for communicating the information regarding the overall quality to the concerned citizens and the policy makers. Factors incorporated in WQI model may differ depending upon the designated use of water. WQI summarizes the large amounts of water quality data into simple terms (for e.g., excellent, good, bad etc.) to report to the managers and the general public in a consistent manner (Saksena *et al.,* 2008). Hence, the study was initiated to assess the quality of irrigation water in Himalayan footh hills of Uttarakhand.

MATERIAL AND METHODS

The present study was carried out at four sites representing different land use pattern due to urbanization (Clock Tower), industrialization with rapid urbanisation at Selaqui, FRI campus has some forest area along with some urban area and Karwapani is a wetland area with some traditional villages. These sites were selected for comparison of water attributes of these areas as

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they might have impacted due to urbanization, industrialization or both. Water samples of surface and ground water were collected from selected sites during summer (March-June), monsoon (July-October) and winter (November-February). Triplicates of each samples were collected from all these sites and analysed for various physico-chemical attributes such as pH, EC, total dissolved solid, bicarbonate and alkali metals by adopting standard procedures (Trivedy and Goel, 1986). Heavy metals in the samples were analyzed by atomic absorption spectrophotometer with Acetylene flame as per the standard methods. WQI was assessed as per methods of Kumari and Chaurasia (2015).

RESULTS AND DISCUSSION

Physico-chemical parameters

Results indicated that pH in summer, monsoon and winter seasons varied from 7.2 to 7.7, 7.2 to 7.3 and 7.1 to 7.3, respectively in surface water whereas, in ground water it varied between 7.2 and 7.3, 7.1 and 7.2 and 7.1 to 7.3, respectively. Results revealed that relatively higher pH was noticed in summer than monsoon season in surface water than ground water and less in monsoon season due to dilution effects (Singh *et al.,* 2006; Rao and Rao, 2010). EC varied from 372.5 to 563.2, 350.7 to 423.0 and 362.9 to 522.6 µScm^{-1} in surface water during summer, monsoon and winter respectively whereas, in the ground water it varied from 351.4 to 364.0, 335.5 to 351.8 and 342.6 to 361.8 µScm^{-1}. In all the three seasons, EC was found to be maximum at the site-II whereas, no significant difference was observed at site I-IV in ground water. This could be due to presence of more ions in the solution state. EC falls under "good" category and this could be attributed to the dilution of salts arising from increased water volume in the river due to addition of rain water.

TDS content was maximum (649.7ppm) during monsoon season and the minimum (385.7ppm) in the summer season at site-I. While in ground water, TDS ranged from 316.7 to 447.3ppm. TDS at site-II in surface water was recorded from 446.7 to 860.0ppm. Similarly, at site-III, TDS varied from 533.3 to 866.7ppm in surface water and between 343.3 to 610.0ppm in ground water. At site-IV, it had the range of 493.3 to 906.7ppm indicating maximum value during monsoon and minimum in summer season. In ground water, the range was between 366.7 and 473.3ppm. According to Gaur *et al.* (2011) seasonal changes result in distinct alteration of TDS value in the groundwater. In general, the highest HCO_3^- was recorded during summer season followed by winter and monsoon seasons, respectively in surface and in ground water. The bicarbonate in surface and ground water ranged from 146.7 to 186.3ppm and 144.5 to 171.3ppm, respectively, irrespective to source and seasons (Table 1).

Table 1: Physico-chemical parameters of surface and ground water

Site	Season	Surface water				Ground water			
		pH	EC (µScm^{-1})	TDS (ppm)	HCO_3^- (ppm)	pH	EC (µScm^{-1})	TDS (ppm)	HCO_3^- (ppm)
Site-I	Summer	7.3	428.5	385.7	174.0	7.2	364.0	316.7	154.3
	Monsoon	7.2	358.6	649.7	153.0	7.2	351.8	447.3	150.3
	Winter	7.2	381.9	453.0	168.0	7.3	361.8	403.3	171.3
Site-II	Summer	7.6	563.3	446.7	186.3	7.3	360.7	336.7	157.3
	Monsoon	7.3	423.0	860.0	161.5	7.1	335.5	476.7	157.3
	Winter	7.3	522.6	683.3	170.0	7.3	342.6	383.3	164.2
Site-III	Summer	7.7	456.3	533.3	175.0	7.2	362.8	443.3	155.0
	Monsoon	7.2	361.8	866.7	148.7	7.2	345.1	610.0	144.5
	Winter	7.1	398.2	620.0	160.7	7.2	360.7	443.3	151.7
Site-IV	Summer	7.2	372.5	493.3	163.7	7.2	351.5	366.7	147.0
	Monsoon	7.2	350.7	906.7	146.7	7.1	345.9	473.3	147.0
	Winter	7.2	362.9	553.3	153.0	7.1	345.9	373.3	148.3

Alkali metals

It was observed from Table 2 that Na concentration in surface and ground water showed the same trend at site-II, where as site-I, site-II and site-IV showed different trends in both surface and ground water during all the three seasons. Ground water with high Na content is not suitable for agricultural activity as it tends to deteriorate soil quality (Mohsin *et al.,* 2013). The maximum concentration of K was recorded in surface water (7.8ppm) during summer and the minimum (2.2ppm) in the monsoon at site-I. However, in ground water, the higher values of K were observed in summer and lower in monsoon. At site-II, concentration of K was recorded maximum in summer and minimum in monsoon in surface and ground water. In ground water, K concentration was recorded highest during monsoon and lowest in summer. Though potassium is extensively found in some of igneous and sedimentary rocks, its concentration in natural waters is usually quite low. This is due to the fact that potassium minerals offer resistance to weathering and dissolution (Jain *et al.,* 2010). The results indicated that Ca content during summer, winter and monsoon varied between 33.0 and 42.9, 30.4 and 40.4 and 25.5 and 29.9ppm, respectively in surface water, whereas in ground water it varied from 22.4 to 35.6, 20.9 to 28.5 and 19.5 to 27.8ppm, respectively (Table 2). The higher Ca concentration was recorded in summer and least in monsoon which may be due to seasonal changes in both surface and ground water. The concentration of Mg in surface water during summer, monsoon and winter seasons varied from 20.8-32.6, 16.6-18.7 and 17.6-29.3ppm, respectively whereas in ground water, it varied from 18.2-28.8, 16.0-17.5 and 17.5-19.7ppm (Banerjee *et al.,* 2013).

Table 2: Alkali metals (ppm) in surface and ground water

Site	Season	Surface water				Ground water			
		Na	K	Ca	Mg	Na	K	Ca	Mg
Site-I	Summer	8.1	7.8	42.5	22.7	6.5	3.5	24.9	20.5
	Monsoon	7.4	2.2	25.5	18.1	4.7	2.1	22.6	17.5
	Winter	8.2	3.6	38.2	25.5	5.9	3.3	23.2	18.9
Site-II	Summer	12.3	18.0	42.9	27.5	7.0	7.7	35.6	28.8
	Monsoon	8.9	10.2	29.6	18.4	4.8	6.9	27.8	16.8
	Winter	11.8	17.6	35.1	27.4	6.8	6.6	28.5	17.9
Site-III	Summer	12.6	8.2	40.6	32.6	7.6	5.1	30.3	19.9
	Monsoon	5.6	5.8	29.9	18.7	4.6	3.8	27.5	16.2
	Winter	11.9	5.6	40.4	29.3	4.7	5.1	28.2	19.7
Site-IV	Summer	6.5	9.4	33.0	20.3	5.3	4.8	22.4	18.2
	Monsoon	4.4	1.8	28.5	16.6	5.4	1.5	19.5	16.0
	Winter	6.6	4.9	30.4	17.6	6.4	5.9	20.9	17.5

Heavy metals

At site-I, Cd concentration varied from 0.004 to 0.007ppm in the surface water. The maximum Cd concentration (0.007ppm) was recorded during summer and the minimum (0.004ppm) during monsoon. However, in ground water, Cd concentration ranged from 0.003 to 0.004ppm and higher concentration of Cd was observed during summer and lower in monsoon. At site-II, Cd varied from 0.001 to 0.007ppm in surface water and from 0.004 to 0.005ppm in ground water and maximum concentration was recorded in winter and minimum in summer. The ranges of Cd content at site-III were 0.005 to 0.01ppm in surface water and 0.004 to 0.005ppm in ground water. The ranges of Cd at site-IV were 0.003 to 0.006ppm and 0.002 to 0.005ppm in surface and ground water, respectively.The maximum Cr concentration (0.078ppm) was recorded in summer and the minimum (0.062ppm) in the monsoon at site-I. At site-II, it ranged between 0.071 and 0.087ppm and maximum concentration was recorded in summer and minimum in monsoon in surface water. In ground water, it varied from 0.065 to 0.067ppm and highest concentration was recorded in summer and lowest in monsoon. Similarly, at site-III, Cr concentration in surface water from 0.049 to

0.070ppm and 0.045 to 0.051ppm in ground water and higher concentration being during summer and lower in monsoon. Surface water at site-IV showed the range of 0.045 to 0.066ppm and 0.038 to 0.053ppm in ground water and higher concentration during summer and lower during monsoon. Weathering of the earth crust is the primary and natural source of the chromium in the surface water (Dixit and Tiwari, 2008).

The maximum Cu concentration (0.068ppm) was recorded in summer and the minimum (0.062ppm) in the monsoon. In ground water, it ranged from 0.042 to 0.047ppm. At site-II, 0.049 to 0.064ppm was recorded in surface water and maximum concentration was recorded in summer and minimum in monsoon. In ground water, it varied from 0.045 to 0.050ppm, highest being in summer and lowest during monsoon. At site-III, Cu concentration in surface water was in the range of 0.040 to 0.061ppm and maximum concentration was recorded during summer and minimum in monsoon. In ground water, it varied between 0.033 to 0.048ppm. At site-IV, it was found in the range of 0.031 to 0.040ppm in surface water and maximum value was observed during summer and minimum in monsoon. Ground water had its concentration between 0.030 to 0.039 ppm. Almost same trend was observed in surface and ground water in this case also.It wasobserved that higher concentration of Copper in the natural water is due to pollution (Jain *et al.,* 2010).

The maximum Pb concentration (0.054ppm) was recorded in summer season and the minimum (0.017ppm) in the monsoon. In ground water, Pb concentration ranged from 0.016 to 0.028ppm and highest concentration was observed during summer and lower in monsoon. At site-II, it ranged between 0.069 and 0.074ppm in surface water and 0.034 and 0.047ppm in ground water and highest being during summer and lowest during monsoon. Lead at site-III in surface and ground water was from 0.042 to 0.069 ppm and 0.037 to 0.045ppm, respectively and again higher concentration was recorded during summer and lower in monsoon. At site-IV, it was found in the range of 0.019 to 0.032ppm in surface and 0.016 to 0.038 ppm in ground water. The highest concentration was observed during summer and minimum during monsoon (Table 3). The causes of increase in the level of Pb and Cr are industrial and agriculture discharge, huge amount of lead from automobile cars and weathering of the earth's crust respectively. Apart from this large, amounts of aqueous effluents also responsible for elevated level of Cd and Cu. Moreover, fertilizers from the agriculture discharge also caused the enhanced level of the heavy metals.

Table 3: Heavy metals (ppm) in surface and ground water

Site	Season	Surface water				Ground water			
		Cd	Cr	Cu	Pb	Cd	Cr	Cu	Pb
Site-I	Summer	0.007	0.078	0.068	0.054	0.004	0.066	0.047	0.028
	Monsoon	0.004	0.062	0.048	0.017	0.003	0.057	0.042	0.016
	Winter	0.006	0.077	0.057	0.035	0.003	0.061	0.046	0.020
Site-II	Summer	0.001	0.087	0.064	0.074	0.005	0.067	0.050	0.047
	Monsoon	0.006	0.071	0.049	0.069	0.004	0.065	0.045	0.034
	Winter	0.007	0.078	0.063	0.071	0.047	0.066	0.049	0.036
Site-III	Summer	0.010	0.070	0.061	0.069	0.005	0.051	0.048	0.045
	Monsoon	0.005	0.049	0.040	0.042	0.004	0.045	0.033	0.038
	Winter	0.009	0.069	0.047	0.049	0.004	0.047	0.044	0.041
Site-IV	Summer	0.006	0.066	0.040	0.032	0.004	0.053	0.039	0.038
	Monsoon	0.003	0.045	0.031	0.020	0.002	0.038	0.030	0.019
	Winter	0.004	0.057	0.039	0.019	0.005	0.047	0.032	0.016

Water quality index

WQI varied from 18.44 to 78.31 in surface water (Fig.1) and from 15.36 to 39.52 in ground water (Fig. 2). On the basis of WQI, surface water of site-I is rated as good to excellent whereas site II as very poor to good. Site III as poor to good and site IV rated as good to excellent.

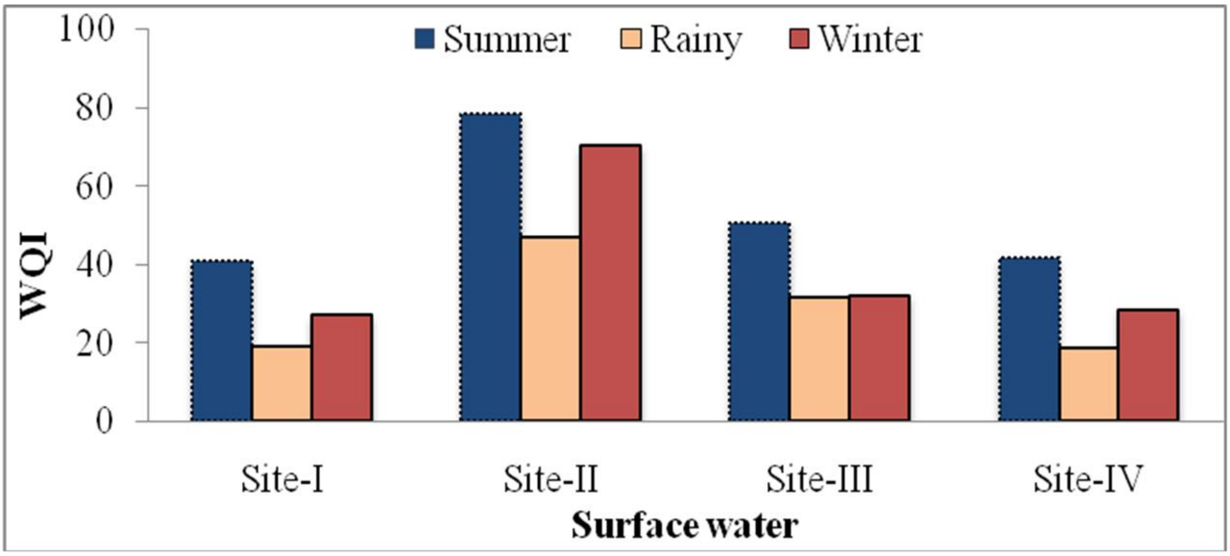

Fig. 1: WQI of surface water at four selected sites during three seasons

On the basis of water quality index (WQI) site-I is rated as excellent, whereas site-II and site-III as good and site IV as good to excellent. Site II and site III are comparatively polluted sites because of more urbanization and development of paint, battery manufacturing and packaging and pharmaceutical industries, the water quality of these two sites are good, which is more likely to become Poor owing to more pollution over the coming years, although ground water of all study sites is good for all purposes including human consumption as per their WQI values.

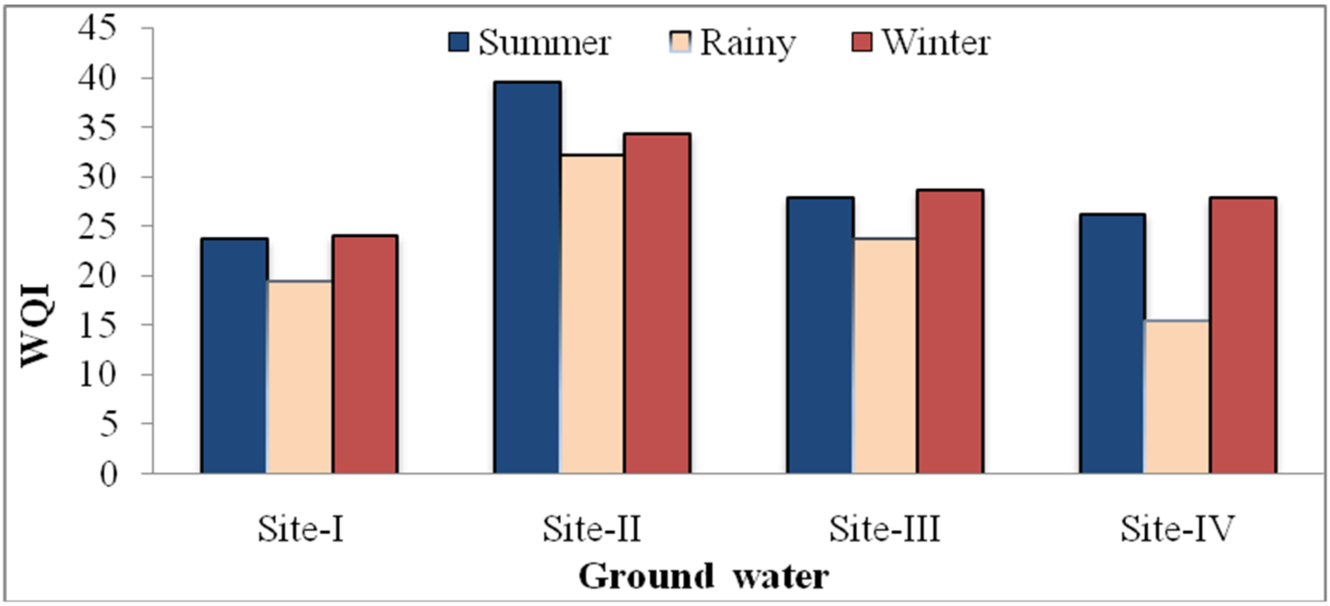

Fig. 2: WQI of ground water at four selected sites during three seasons

From the results, it may be concluded that water from both the sources were of good quality in respected of physico-chemical parameters and heavy metals contents. Water Quality Index (WQI), ranged from 18.44 to 78.31 in surface water and from 15.36 to 39.52 in ground water. Water quality rating showed that, in the surface water, site I and site IV were rated as good to excellent whereas, site II and site III were rated as poor to good. Ground water in all the sites have been rated as good to excellent.

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