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Assessment of Seasonal Variation in Physico-chemical Characteristics of Spring Water: A Case Study of Kyunja Gad Watershed, District Rudraprayag, Uttarakhand

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Abstract—*The present study was carried out to assess the seasonal variations of spring water quality of different locations of Kyunja Gad Watershed, District Rudraprayag, Uttarakhand. Total 7 springs water samples were collected from Kyunja Gad Watershed. Spring water samples collected in winter, pre-monsoon, monsoon and post-monsoon seasons of the year 2016 were analyzed for various water physico-chemical characteristics, viz. pH, DO, temperature, Turbidity, Electrical conductivity, Total dissolved solids, Chloride, Total hardness, Fluoride, Nitrate, Sulfate and Iron. The analyses was done according to standard methods for water examination and reported based on the WHO prescribed limit for drinking water. The Result showed the variations of the analyzed parameters in water sample as follows: Turbidity 0.01-1.4 NTU; pH 6.2-8.0; DO 5.19-15.24 mg/l; TDS 31-199 mg/l; Electrical conductivity 61.5-397 µs/cm; Total hardness as 20-176 mg/l; Chloride 2.5-28 mg/l; Nitrate 0.5-10.3 mg/l and Iron 0.1-1.2 mg/l respectively. The analyzed physio-chemical parameters of water samples from all the 7 springs were permissible limit of APHA/ WHO/ BIS 10500: 2012 water quality guidelines.*

Keywords*: Water quality, physico-chemical characteristics, Seasonal variations, Kyunja Gad Watershed.*

1. INTRODUCTION

Water is at the core of sustainable development and is critical for socio-economic development, healthy ecosystems and for human survival itself. It is vital for reducing the global burden of disease and improving the health, welfare and productivity of populations. The village community in the state depends upon four types of water sources. These were Dhara, Naula, Tap and River. The average volume of water collected was found to be 118.6 liters from dhara, followed by 74.44 liters, 29.59 liters and 8.55 liters from naulas, Taps nad River respectively (Fahimuddin, 2011). Spring water (dhara) use as main source of drinking and domestic purposes In the Kyunja Gad Watershed, district Rudraprayag, Uttrakhand. Spring is a natural source of groundwater and points on the surface of the earth through which groundwater emerges and flows. The availability of water determines the location and activities of humans in an area and our growing population is placing great demands upon natural fresh water resources. Any reduction in water supply or water quality will have profound impacts not only on village drinking water, but also on regional livelihoods, health, biodiversity, agriculture, tourism, power generation, and industry. Considering this situation a good knowledge of the qualities of spring water is necessary to guide its suitability for use. In this study, attempt is made to assess the seasonal variation in the physico-chemical characteristics of spring water in the Kyunja Gad Watershed, district Rudraprayag, Uttrakhand.

2. STUDY AREA

The present study area is Kyunja Gad Watershed lies in the Augustmuni block of District Rudraprayag, Uttarakhand. Kyunja Gad Watershed is located in north part of the district. Geographically, the Watershed lies between the $30^0$28' to 30^0 22'7" N latitudes and $79^0$4'2" to $78^0$10'6" E longitude which covers an area of 32.14 km^2. Kyunja Gad is a tributary of river Mandakini. The elevation in the Kyunja Gad Watershed ranges from 800 to 3,000 m above MSL. Most of the village settlements are situated between 800 and 2,400 m elevation. The study area falls in Survey of India (1:50,000) toposheets No 53 N/3. The entire Kyunja Gad Watershed covered of 46 villages. The total population of Watershed is 13522 according to 2011 census which is 5.58 % of the district population.

Geologically the study area lies in the Lesser Himalayan region. Mainly Phyllite, Granite gnenisses are exposed in the Kyunja Watershed. While the Partoli quartzites are exposed in the upper part of the Bhanaj ridge.

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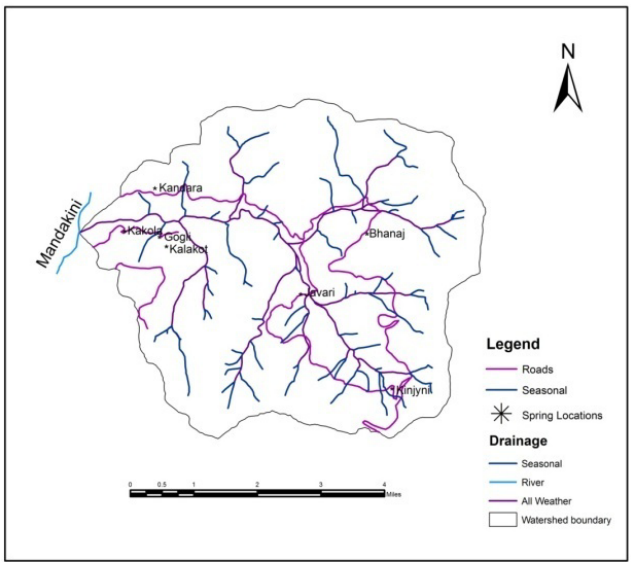

Figure 1: Location map of the springs in the study area.

3. MATERIALS AND METHODS

The methods adopted for this study were field investigation/sampling and laboratory analyses. A total number of 7 samples were collected from Kyunja Gad Watershed, District Rudraprayag, Uttarakhand. The samples were collected during all four seasons winter (December to February) pre-monsoon (March to May), monsoon (June to September) and post-monsoon (October to December) with their GPS coordinates during 2016.

Table 1: Sampling sites in the Kyunja Gad Watershed.

S. No.	Location	Sampling ID	Altitudes	Latitude	Longitude
1.	Kinjani	S1	1857mt.	300 23' 514"	790 08' 978"
2.	Bhanaj	S2	1725mt.	300 25' 515"	790 08' 488"
3.	Jawari	S3	1349 mt	300 24' 668"	790 07' 743"
4.	Kalakot	S4	1215mt.	300 25' 279"	790 05' 334"
5.	Kandara	S5	1267mt.	300 26' 139"	790 05' 248"
6.	Gugaly	S6	1148 mt.	300 25' 379"	790 05' 611"
7.	Kakola	S7	1034 mt.	300 25' 48 "	790 04' 758"

The sample was collected into 2 L polyethylene bottles separately which were pre-cleaned with concentrated hydrochloric acid and distilled water and preserved for further analysis in a refrigerator to avoid contamination. Water quality parameters such as pH and Temperature of collected water samples were measured on the sampling spot by using portable digital temperature meter (ADWA AD 131). TDS and EC of collected water samples were measured using ADWA EC 108 using a conductivity probe (A 76309) on the sampling spot. The instrument was first calibrated (Buffer solution 84 µs) according to the instruction given by manufacturer and then measurement was being taken. DO was measured by the DO measuring meter (ADWA AD 630), using Galvanic probe which was calibrated to the prescribed standard before analysis of the sample and then measurement was being taken. Turbidity was measured in accordance with Standard Method 2130B (APHA et al., 1998) with a Hach Turbidimeter, model TN100. The turbiditymeter was calibrated using stable cal calibration standards of less than 0.1, 20, 200, 1000 and 4000 NTU (Hach Calibration Standards Catalog Number 26621-05). While other physico-chemical variables were studied using by the standard methods as appropriate (American Public Health Association (APHA 2005).

4. RESULT AND DISCUSSION

The parameters such as pH, temperature, electrical conductivity, turbidity, TDS, alkalinity, total hardness, chloride, sulfate, nitrate and Iron for samples from Kyunja Gad Watershed were analyzed during different seasons of year 2016 (winter, pre-monsoon, monsoon and post-monsoon) and the results are given in Table 2. Seasonal discharge of selected springs was measured during the course of study. The maximum discharge value 6297.38 l/h at site S7 was recorded in the monsoon season and minimum 428.06 at site S3 in the pre-monsoon season. The maximum temperature value 22.3°C at site S6 recorded in the monsoon season and minimum 11°C at site S1 in the winter season of 2016.The temperature values recorded for water in the study area were within the EPA limit of 30°C. The pH value was recorded maximum 8.3 in Post-monsoon season and minimum 6.2 in the monsoon period of 2016 and all the water samples analyzed have concentration within the safe limit of 6.5 to 8.5 standard set by the WHO and BIS. The DO varied from maximum 17.5 ppm recorded during the winter season and minimum 5.04 ppm in the monsoon season. The TDS concentration, ranging between 91-96 ppm in winter season, highest value of TDS 199 mg/l was recorded for the post-monsoon season and the lowest value 31 mg/l was recorded for the monsoon season. A high electrical conductivity value was recorded from the sampling site SPR 11a which is 397 µs during the post-monsoon. The high value may be due to the domestic effluent discharge near to the site and the lowest value 61 mg/l was recorded for the winter season. Nitrate concentration in the study area ranges from 0.5-4.53 mg/l during winter, 1-4.9 mg/l during pre-monsoon, 3.5-7.9 mg/l during monsoon and 8.2-10.5 mg/l during post-monsoon. The Nitrate varied from maximum 10.5 mg/l at site S6 in the post-monsoon season and minimum 0.5 mg/l in the winter season at the S5 dhara. The maximum iron content was found to be 1.8 mg/l in S7 in winter season and the lowest value 0.1 mg/l was recorded for the post-monsoon season. The sulfate concentration in sampling site ranged between 5.3-17.9

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mg/l during winters, 6.6-31.4 mg/l during pre monsoon, 5.6-32.5 mg/l during monsoon and 7.3-18.6 mg/l during post-monsoon. Hardness is an important criterion for ascertaining the suitability of water for domestic, drinking and many industrial uses (Karanth, 1994). The total hardness of study sites 20-89 mg/l during winters, 60-140 mg/l during pre monsoon, 36-176 mg/l during monsoon and 35-151 mg/l during post–monsoon. The highest concentration of chloride 28 mg/l was recorded in the winter season and lowest concentration 2.5 mg/l was recorded in the monsoon season 2016.

The correlation co-efficient between the various physicochemical parameters were calculated and presented in the Table 3. In winter season significant positive relationship was obtained between various variables such as discharge and EC (0.79), Discharge and total Hardness (0.85) pH and Sulfate (0.76), EC and sulfate (0.89), EC and Total Hardness (.95), Iron and Total hardness (0.77) and sulfate and Total hardness (0.92) significant at the 0.01 level.

Similarly, in pre-monsoon season a strong positive relationship was obtained between various variables such as discharge and total hardness (0.78), pH and nitrate (0.86), TDS and Nitrate (0.92), EC with nitrate (0.93). A strong negative relationship was obtained between temperature and nitrate (-0.79), turbidity and pH (-0.75).

Similarly, in monsoon season strong relationship was obtained between discharge and TDS (0.79), discharge with EC (0.79), discharge with total hardness (0.89), pH and TDS (0.97), pH and EC (0.97), pH with total hardness (0.90), TDS and nitrate (0.78), TDS and total hardness (0.97) EC and nitrate (0.78), EC and total hardness (0.97). A strong negative relationship was obtained between nitrate and iron (-0.81).

Similarly post monsoon season strong relationship was obtained between discharge and TDS (0.87), discharge and EC (0.87), discharge and total hardness (0.89), turbidity and chloride (0.76), TDS and total hardness (0.96), EC and total hardness (0.96) and iron and sulfate (0.95). A strong negative relationship was obtained between discharge and pH (-0.74).

5. CONCLUSION

The quality of spring water represents the general water quality of the ground-water system. Most spring water is of excellent quality for drinking, domestic and other purpose. In the present study, the correlation coefficient of 9 Physic-chemical parameters of the springs revealed that all the parameters were more or less correlated with one another, especially strong correlations observed between pH and TDS (0.97), pH and EC (0.97), TDS and total hardness (0.97), EC and total hardness (0.97) in monsoon season and nitrate and iron (-0.81) was found highly negative correlation in monsoon season.

6. ACKNOWLEDGEMENT

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Table 2 Physico-Chemical parameters analysis of spring water samples in different seasons in the Kyunja Gad

Watershed. Sample ID	Discharge	Temp.	Turbidity	pH	DO	TDS	EC	No□-	Fe	SO42-	Total Hardness	Cl-
Measuring Unit	l/h	°C	NTU		ppm	ppm	µs/cm	mg/l	mg/l	mg/l	mg/l	mg/l
Desirable Unit (IS 10500:2012)		-	1	6.5-8.5	-	500		45	0.3	200	200	250
Permissible Unit (IS 10500:2012)		-	5	No relx	-	2000		100	1.0	400	600	1000
Winter (RESULT)												
S1	1141.50	11	0.35	6.6	15.6	54	136	4.5	0.2	5.81	38	25
S2	1604.46	12	0.04	7.5	11.6	54	169	2.7	0.2	14	51	13
S3	499.74	13	0.39	7.1	17.5	57	83	2.4	0.2	5.82	20	14

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S4	610.69	15	0.06	6.9	17.5	51	71	2.9	0.7	4.43	24	14
S5	1482.24	16	0.42	7.1	17.5	96	61	0.5	0.2	5.3	30	19
S6	468.37	15	0.08	7.2	12.4	62	67	4.5	0.7	8.91	29	27
S7	2074.93	16	0.09	7.4	13.8	64	241	2.5	1.8	17.9	89	28
Average	1125.99	14	0.20	7.1	15.1	63	118	2.9	0.6	8.9	40	20
Max	2074.93	16	0.42	7.5	17.5	96	241	4.5	1.8	17.9	89	28
Min	468.369	11	0.04	6.6	12.4	51	61	0.5	0.2	5.3	20	13
Pre-Monsoon (RESULT)												
S1	870.88	17.7	0.12	7.6	12.41	76	159	2.9	0.6	8.2	72	19.5
S2	1168.36	17.2	0.01	7.7	14.78	137	276	4.7	0.3	6.6	124	21.3
S3	428.06	19.5	0.17	7.5	12.16	53	105	2.1	0.3	18.3	44	19.3
S4	627.00	18.3	0.03	7.7	12.61	48	99	4.9	0.3	31.4	36	17.4
S5	1241.92	21.3	0.01	8.0	12.69	33	76	1	0.3	7.87	60	17.2
S6	591.13	18.1	0.07	7.5	14.69	47	99	2.8	0.2	8.97	76	18.6
S7	1598.82	19.3	0.15	7.1	15.24	192	386	1.6	0.3	8.31	140	14.7
Average	932.31	18.8	0.08	7.6	13.51	84	171	2.9	0.3	12.8	79	18.3
Max	1598.82	21.3	0.17	8	14.78	192	386	4.9	0.6	31.4	140	21.3
Min	428.06	17.2	0.01	7.1	12.16	33	76	1	0.2	6.6	60	14.7
Monsoon (RESULT)												
S1	2519.69	16.3	0.33	6.7	6.59	76	152	6.1	0.3	9.95	68	4.2
S2	5760.00	17.9	0.42	7.0	6.29	117	236	6.2	0.2	5.28	108	2.5
S3	2907.13	21.1	0.16	6.5	6.33	47	95	3.5	1.2	30.1	36	2.8
S4	3162.52	21.2	0.72	6.2	5.04	31	62	5.3	0.6	7.31	40	4.4
S5	2625.34	22.2	0.39	6.6	5.36	79	158	6.5	0.3	32.5	56	2.5
S6	1679.30	22.3	1.4	6.8	6.01	76	151	6.4	0.8	6.74	44	6.1
S7	6297.38	18.9	1.07	7.4	6.31	186	373	7.9	0.2	5.6	176	2.5
Average	3564.48	20.0	0.64	6.7	5.99	87	175	6.0	0.5	13.9	75	3.6
Max	6297.376	22.3	1.4	7.4	6.59	186	373	7.9	1.2	32.5	176	6.1
Min	1679.3	16.3	0.16	6.2	5.04	31	62	3.5	0.2	5.6	36	2.5
Post-Monsoon (RESULT)												
S1	1309.09	16.8	0.16	7.9	6.86	75.3	146.5	8.3	0.0	7.30	59	3.3
S2	2400.00	17.2	0.36	7.4	6.01	134	269	10.3	0.0	9.00	98	5.1
S3	757.89	18.2	0.46	7.8	5.19	57.5	115.3	8.4	0.1	10.3	35	4.1
S4	960.00	16.1	0.6	7.5	7.90	44.6	89.3	8.2	0.1	10.7	54	9.9
S5	2057.14	20.2	0.31	7.2	5.86	93.8	187.6	9.1	0.2	15.9	62	6.7
S6	576.00	18.3	0.96	8.3	5.73	83.3	166.3	10.5	0.2	16.2	46	10.0
S7	2880.00	17.8	0.35	7.4	7.06	199	397	8.5	0.2	18.6	151	7.7
Average	1562.88	17.8	0.46	7.6	6.37	98	196	9.0	0.1	12.6	72	6.7
Max	2057.143	20.2	0.96	8.3	7.9	199	397	10.5	0.2	18.6	151	10
Min	576	16.1	0.16	7.2	5.19	44.6	89.3	8.2	0.1	7.3	35	3.3

Table 3 Correlation matrix showing the relation between different water quality parameters during the monsoon, pre-monsoon, monsoon and post-monsoon seasons of 2016.

Correlations Winter Season												
	Discharge	**Tempe.**	**Turbidity**	**pH**	**DO**	**TDS**	**EC**	**No3-**	**Fe**	**SO42-**	**Total Hardness**	**Cl-**
Discharge	1	0.14	-0.11	0.45	-0.32	0.33	0.79*	-0.40	0.42	0.71	0.85*	0.25
Temp.		1	-0.17	0.33	0.16	0.57	-0.11	-0.48	0.59	0.11	0.19	0.25
Turbidity			1	-0.50	0.67	0.50	-0.37	-0.35	-0.52	-0.55	-0.40	-0.05
pH				1	-0.61	0.13	0.43	-0.34	0.37	0.76*	0.51	-0.08
DO					1	0.27	-0.51	-0.44	-0.26	-0.74	-0.51	-0.33
TDS						1	-0.25	-0.71	-0.07	-0.13	-0.02	0.15
EC							1	0.08	0.62	0.88**	0.95**	0.34
No3-								1	0.06	0.04	-0.04	0.42
Fe									1	0.66	0.76*	0.57

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SO42-										1	0.91**	0.36
Total Hardness											1	0.48
Cl-												1
Correlations Pre-monsoon Season												
Discharge	1	0.24	-0.12	-0.19	0.54	0.73	0.75	-0.32	0.05	-0.56	0.78*	-0.46
Temp.		1	0.04	0.24	-0.30	-0.26	-0.25	-0.79*	-0.24	-0.03	-0.25	-0.56
Turbidity			1	-0.75	-0.08	0.27	0.26	-0.43	0.26	-0.03	0.08	-0.24
pH				1	-0.52	-0.68	-0.67	0.15	0.06	0.09	-0.53	0.42
DO					1	0.72	0.72	0.06	-0.45	-0.49	0.86*	-0.18
TDS						1	1.0**	0.02	0.03	-0.38	0.92**	-0.26
EC							1	0.01	0.04	-0.40	0.93**	-0.27
No3-								1	0.02	0.46	-0.06	0.51
Fe									1	-0.15	-0.06	0.21
SO42-										1	-0.66	-0.13
Total Hardness											1	-0.14
Cl-												1
Correlations Monsoon Season												
Discharge	1	-0.47	0.02	0.70	0.27	0.79*	.794*	0.44	-0.54	-0.39	0.89**	-0.65
Temp.		1	0.31	-0.42	-0.67	-0.40	-0.40	-0.24	0.55	0.46	-0.50	0.25
Turbidity			1	0.38	-0.12	0.35	0.34	0.57	-0.05	-0.58	0.26	0.59
pH				1	0.60	0.97**	0.97**	0.73	-0.52	-0.40	0.90**	-0.31
DO					1	0.45	0.45	0.05	-0.02	-0.19	0.40	-0.13
TDS						1	1.0**	0.78*	-0.62	-0.38	0.97**	-0.42
EC							1	0.78*	-0.62	-0.38	0.97**	-0.43
No3-								1	-0.80*	-0.49	0.73	-0.03
Fe									1	0.40	-0.66	0.33
SO42-										1	-0.45	-0.41
Total Hardness											1	-0.49
Cl-												1
Correlations Post-monsoon Season												
Discharge	1	0.16	-0.58	-0.74	0.18	0.87**	0.87**	0.03	0.05	0.32	0.89**	-0.16
Temp.		1	0.01	-0.18	-0.66	0.14	0.14	0.26	0.63	0.58	-0.08	-0.02
Turbidity			1	0.59	-0.15	-0.27	-0.26	0.50	0.46	0.35	-0.34	0.76*
pH				1	-0.26	-0.38	-0.39	0.27	-0.02	-0.12	-0.49	0.10
DO					1	0.08	0.07	-0.49	-0.12	-0.06	0.34	0.36
TDS						1	1.00**	0.18	0.24	0.54	0.96**	0.01
EC							1	0.19	0.25	0.54	0.96**	0.01
No3-								1	0.09	0.19	0.00	0.24
Fe									1	0.94**	0.14	0.64
SO42-										1	0.43	0.61
Total Hardness											1	0.05
Cl-												1
**. Correlation is significant at the 0.01 level (2-tailed).												
*. Correlation is significant at the 0.05 level (2-tailed).												

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