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Water Quality Assessment In Upper Reaches Of Yamuna River Upto Downstream Of Dakpathar Barrage, Uttarakhand, India.

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Abstract: Rivers are among the leading suppliers of water, nutrients, and habitat for all living creatures. It's deteriorating day to day with natural and anthropogenic activities. My Study area lies from Yamunotri temple(31° 0' 0.63238''N, 78° 27' 46.22638''E) to downstream of Dakpathar Barrage(30° 30' 8.7237''N, 77° 47' 27.61861''E). Few studies have been conducted on the Upper Yamuna River compared to the Lower Yamuna River. Still, people are also using the Upper Yamuna River for domestic and agricultural purposes, so it is essential to know its quality. One widely used method for assessing surface water quality is the water quality index (WQI) model. It aggregates vast volumes of data on water quality into a single value or index using aggregation algorithms. Based on regional water quality standards, the WQI model has been used globally to assess surface water and groundwater quality. Water samples of Yamuna River from 17 locations in January, May and October of 2022 are collected, 15 physiochemical parameters pH, TDS, EC, DO, temperature, alkalinity, Fluoride, Sulfate, Chloride, Nitrate, Ammonium, Sodium, Magnesium, Potassium, Calcium and Total Hardness was analysed, and finally water quality index was calculated. Average value of WQI lies from 10.96(R12) to 57.8(R1) in January, 112.30(R3) to 259.06((R14) in May and 20.95(R12) to 102.85(R3) in October. The findings showed that while the water quality improved in January, it was unfit for human consumption in May and October. We should not use the river water for drinking purposes without treatment.

Index Terms - **Yamuna River; Water Quality; Geology; Hydrology; Physiochemical.**

1. INTRODUCTION

The quality assessment is done to determine the nature of water by calculating the presence of different parameters. Human activities include mining, industrial, sewage, agricultural and domestic waste disposal in the river**(Jindal & Sharma, 2011; Lobato et al., 2015; Singh et al., 2020)**and natural waste from hydrological, climatic, lithological, topographic, soil erosion and atmospheric **(Magesh et al., 2013; Uddin**

et al., 2018). These days, the issue is not just one of access to potable water but also one of the water's suitability for agriculture and drinking. In India, 70% of river water is contaminated, and some river water is of inadequate quality to drink**(Jindal & Sharma, 2011; Ramakrishnaiah et al., 2009).**

To know the water quality, samples from various locations were collected, parametres of interest were selected, and a single value called WQI was devised. WQI is a numerical expression indicating various parameters and makes data accessible to understood by people**(Bordalo et al., 2001; Brown et al., 1970; Cude, 2001; Horton, 1965; Štambuk-Giljanović, 1999)**. WQI helps in decision-making and management of water**(Debels et al., 2005).**

Water quality after Delhi is worse, and there is very little study in the upper part of the Yamuna River. Surface water is deteriorating due to human waste and low dilution capacity.

River Yamuna is the freshwater system and one of the major tributaries of Ganga. It travels through mountainous regions and several villages. People depend on the river water for domestic and agricultural purposes. Hence, it is essential to know its water quality. Its quality is declining day to day because of anthropogenic and natural sources. Yamunotri is also one of the pilgrimage sites, and there is too much rush from April to October, with a peak in May to September every year because this is the best time for pilgrimage. During this time, hotels are packed. There is also good agriculture in this valley. It is a spiritual faith because bathing in the Yamuna River, offering flowers and milk, and immersion in idols increase organic pollution. Washing cloth, cattle wading, Animal husbandry, Dumping garbage and dead bodies, agricultural residues, fertilizers, and open defecation are also significant problems. These pollutants accumulate during dry seasons, mix with river water during monsoon, percolate to the ground, and pollute groundwater. Deforestation and forest fires are also significant causes of the declining quality and quantity of water. Due to this, the soil erodes quickly, and the soil, rock fragments, and ashes mix with the rainwater or snow melt, adding to the river and increasing the pollutants. All these things not only pollute the river Yamuna but also decline the river's self-purification capacity.

2. Study Area

The study was conducted on the upper reaches of Yamuna River, which lies between Yamunotri temple(31° 0' 0.63238"N, 78° 27' 46.22638"E) to downstream of Dakpathar Barrage(30° 30' 8.7237"N, 77° 47' 27.61861"E) shown in **map 1**. Yamuna is one of the most important rivers; the river flows from Higher, lesser, outer Himalayas and through Doon gravels.

The river starts from Saptrishi Kund(4200)**(Biyani, 1991)** and flows through the Higher Himalayas, Lesser, Outer Himalayas and Doon gravels**(Gahlaut et al., 2021)**. MCT passes through Trikhli, Wazri and Paligad of Yamuna Valley; it divides metapeletic and metabasic crystalline rock of the Higher Himalayas (Hanging wall of MCT) of Proterozoic age from Middle Proterozoic Lesser Himalayas(Footwall of MCT) designated as Paligad formation comprises Quartzite and marble **(Biyani, 1991, 1995, 1998)**. MCT is renamed Munsiari and Vaikrita Thrust (inner region of Higher Himalayas)**(Valdiya, 1980)**. Rocks of Vaikirta are not present in the study area. Eyelid windows of Paligad Quartzite are present in Banas-Phulchatti, Jankichatti and Yamunotri**(Hatcher, 1990)**.

MBT passes through the Kalsi, the southern part of which is the Outer Himalayas, and floodplains were deposited by rivers in the past **(Valdiya, 1980)**. The area falls in a tropical environment, coldest in January and warmest in the month of July. Summer monsoon occurs from June to September.

3. MATERIALS AND METHODS

3.1. Sample collection: Water samples from 17 locations (R1 to R17) were collected from the Yamuna River from Yamunotri temple to the downstream of Dakpathar Barrage for three months in 2022, i.e., January, May, and October. Standard procedures were followed for sampling and determination of all physicochemical parameters**(Association, 1926; Michael, 1984; Rice et al., 2012)**. Temperature, pH, Conductivity, TDS, and DO were tested with a handheld pH tester for temperature and pH, a multiparameter for TDS, and EC and DO meter for the dissolved meter on the field. Alkalinity by titration method and chemistry samples for Fluoride, Sulfate, Chloride, Nitrate, Ammonium, Sodium, Magnesium, Potassium, and Calcium are taken to the laboratory and analysed by spectrophotometer. Hardness was calculated using the formula. $\boldsymbol{Hardness = 2.5ca^{2+} + 4.1Mg^{2+}}$ **(Todd & Mays, 1980, 2004).**

3.2. Water Quality Index (WQI): Many methods exist to determine water quality, but I have chosen the weighted arithmetic water quality index**(Brown et al., 1972; Horton, 1965).**

WQI=$\sum_{n=1}^{n} QnWn / \sum_{n=1}^{n} Wn$

Where n is the number of parameters used, Qn is the quality rating.

$Qn = \frac{Vn - Vid}{Sn - Vid} * 100,$

Vn = observed value, Sn is standard permissible value, Vid ideal value, i.e., 14.6 for DO, 7 for pH and 0 for all other parameters.

Wn= k/Sn, where Wn is the unit weight, K=proportionality constant

K=1/($\sum 1/Sn$)

Standard Water quality parameters for drinking purposes are selected from various agencies like "*ICMR (Indian Council of Medical Research), WHO(World Health Organisation, ISI(Indian Standards Institution and BIS(Bureau of Indian Standards)*". These standard value quality ratings (Qn) and unit weight (Wn) are calculated shown in **Table 1**.

WQI for the human consumption is given by (Chatterjee & Raziuddin, 2002) are as shown in **Table2**.:

4. RESULTS AND DISCUSSION

Water samples from 17 locations were collected in January, May, and October, 2022. The first sample (R1) is taken just before the Yamunotri temple; water is expected to be clean here because there are no anthropogenic activities up to this point. R2 is the location downstream in the area from where settlement started. Water quality parameters were analysed like Temp, pH, TDS, EC, DO, Alkalinity, Fluoride, Sulfate, Chloride, Nitrate, Ammonium, Sodium, Magnesium, Potassium, Calcium and Total Hardness, shown by maps/graphs **Graph 1 to Graph 5** and **Map 2 to Map 12.**

An increase in temperature will increase the rate of chemical reaction. Fluctuation in temperature depends on sampling time, season, location and tributaries entering the river**(Ahipathy & Puttaiah, 2006)**. The average temperature of the study area ranged from 1.3 ^{o}c to 17.1^{o}c in January, 4.9 ^{o}c to 31.8 ^{o}c in May, and 5.6 ^{o}c to 27.9 ^{o}c in October, the temperature showing variations due to geographical location and trends in air temperature. Temperature is directly related to conductivity, Total Hardness, and TDS and is inversely associated with pH and DO**(Ahipathy & Puttaiah, 2006)**. pH is directly related to DO and inversely related to temperature and TDS**(Ahipathy & Puttaiah, 2006).** pH fluctuates in all seasons in different locations, and it is slightly alkaline.

Alkalinity: Bicarbonate alkalinity is dominant in all samples, whereas bicarbonate and carbonate alkalinity are present in some samples R2 and R3 of January, R17 of May and R8, R13 and R14 of October. It directly affects EC, temperature, Hardness and TDS**(Ahipathy & Puttaiah, 2006).**

Fluoride: The standard limit of fluoride is 1ppm; consuming more than this may cause dental problems. All samples are less than one ppm except R1 (1.95) in January.

Chloride, Sulfate, Nitrate, Sodium, and Magnesium were present in the sample of all three months within the standard range shown in Table No. 1. Ammonium was present in 4 locations (R1, R2, R6, and R14) during January, all within standard values. It is present in all samples during May and October. In May, the water is not suitable for drinking because ammonium is present in more than the standard values, but during October, it is better than in May. Only one sample (R3) has more than the standard value; all other samples are within standard values.Potassium and calcium for all months are within range except R14 (11.27) in May for potassium and R8 (81.25) in October for calcium, which is more than the standard value.

Total Hardness: It is directly related to EC, alkalinity, chloride, temperature, TDS, Sulphate and potassium**(Ahipathy & Puttaiah, 2006)**. Total Hardness and alkalinity are related to the presence of Calcium and Magnesium and also due to surrounding rocks**(Ikomi & Emuh, 2000; Özdemir, 1995)**. It is classified as "*soft, moderately hard, hard and very hard for 0-60mg/l, 60-120mg/l, 120-180mg/l and >180mg/l respectively*" **(USEP, 1986)**. The hardness of the study area falls from 41.55(R1) to 139.70(R16) in January, 27.71(R1) to 125.43(R16) in May and 35.31(R1) to 278.64(R8) in October.

These parameters are used to analyze WQI throughout the three months displayed in **Graph 6 and in Table 3**, the results demonstrate that the average values of WQI lies from 112.30(R3) to 259.06(R14) in May, 20.95(R12) to 102.85(R3) in October, and 10.96(R12) to 57.8(R1) in January The results demonstrated that although the water quality had improved by January, in May and October it was still unsafe for human consumption. Without treatment, we shouldn't utilize river water for drinking.

5. CONCLUSIONS

In the study, the WQI of Yamuna River was calculated from Yamunotri downstream of Dakpathar Barrage in January 2022, May 2022, and October 2022. It was found that water quality varies in the range of WQI. Temperature, EC, TDS, Salinity, and Alkalinity are minimal at R1 in all three months, where water directly comes from meltwater from the snow-capped peaks. The temperature fluctuates downstream because it depends on sampling time, season, location and tributaries entering the river. pH varies from 6.5(R4) to 8.1(R17), 7.21(R1) to 8.15(R10) and 6.5(R8) to 8.1(R17) in month of January, May and October respectively.

Fluoride, Sulfate, Chloride, Nitrate, Ammonium, Sodium, Magnesium, Potassium, Calcium and Total Hardness were found in all samples of all three months, but ammonium was found in R1, R6 and R14 during January and in all the samples during May and October.

Overall, May's quality is lower than January's, October's quality is higher than May's but still beyond the allowable limit, and January's quality is better. Water quality during January varies from 10.96(R12) to 57.8(R1), which is excellent to fair quality in January, during which there is no pilgrimage at the place and outer input is less because it is the time of snow deposition. During May, the pilgrimage at the peak, the effluent from the hotels is more, which adds to the river snow melting, which directly adds to the rivers and water quality ranging from 112.29(R3) to (259.06), i.e., very poor to unfit and require treatment before use. During October, water quality ranges from 20.94(R12) to 102.85(R3), i.e., excellent to deplorable conditions. It is better than in May but is worse than in January.

Figures and Tables

Table. 1. Standard Value

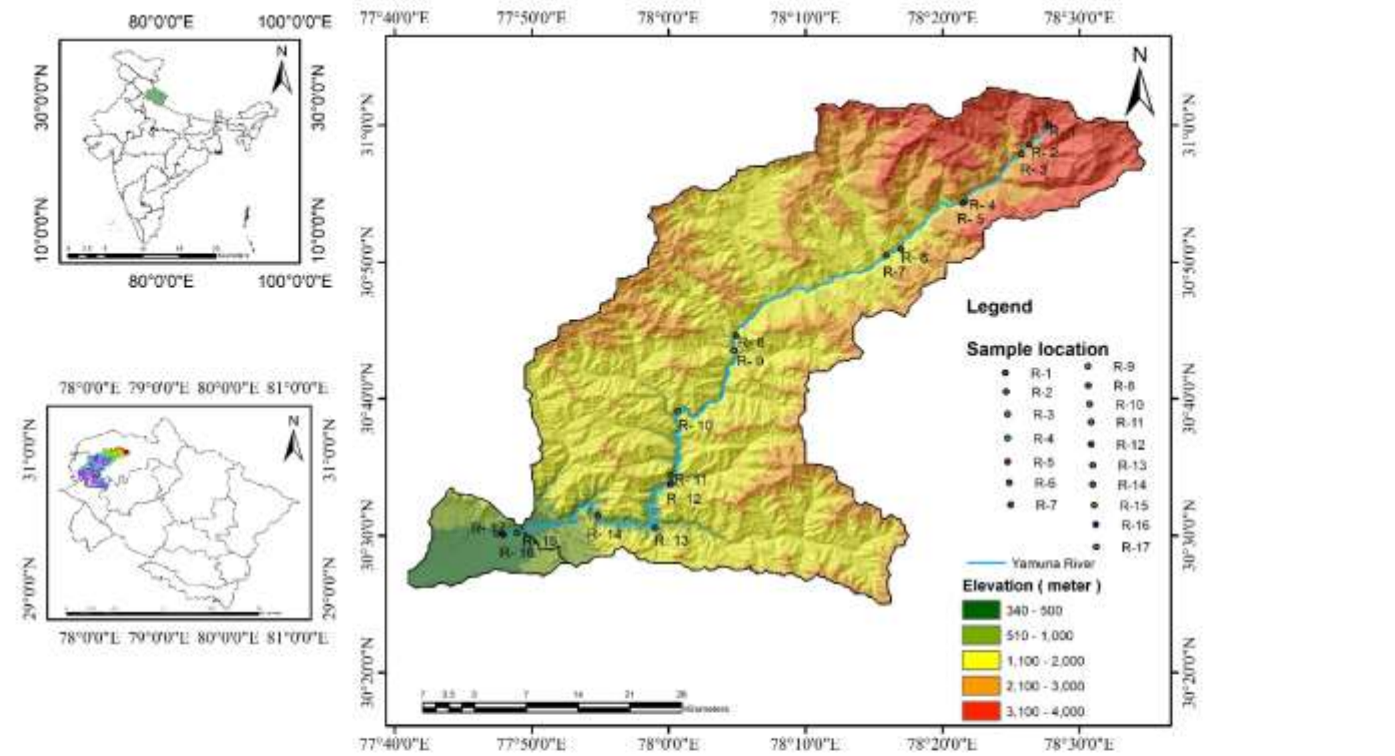
S.No.	**Parameters**	**Standard value (Sn)**	**Recommending Agency**	**(Vid)Ideal value**	**K-value**	**Unit weight**
1	pH	8.5	ISI	7	0.278133	0.032722
2	EC	300	ICMR	0	0.278133	0.000927
3	TDS	500	BIS	0	0.278133	0.000556
4	DO	5	ICMR	14.6	0.278133	0.055627
5	Alkalinity	200	BIS	0	0.278133	0.001391
6	Fluoride	1	BIS/ICMR	0	0.278133	0.278133
7	Chloride	250	BIS/ICMR	0	0.278133	0.001113
8	Sulfate	200	BIS	0	0.278133	0.001391
9	Nitrate	45	BIS	0	0.278133	0.006181
10	Sodium	20	WHO	0	0.278133	0.013907
11	Ammonium	0.5	ICMR/ ISI	0	0.278133	0.556266
12	Potassium	10	WHO	0	0.278133	0.027813
13	Magnesium	30	BIS/ICMR	0	0.278133	0.009271
14	Calcium	75	BIS/ICMR	0	0.278133	0.003708
15	Total Hardness	300	BIS/ICMR	0	0.278133	0.000927

Table 2. WQI Standards

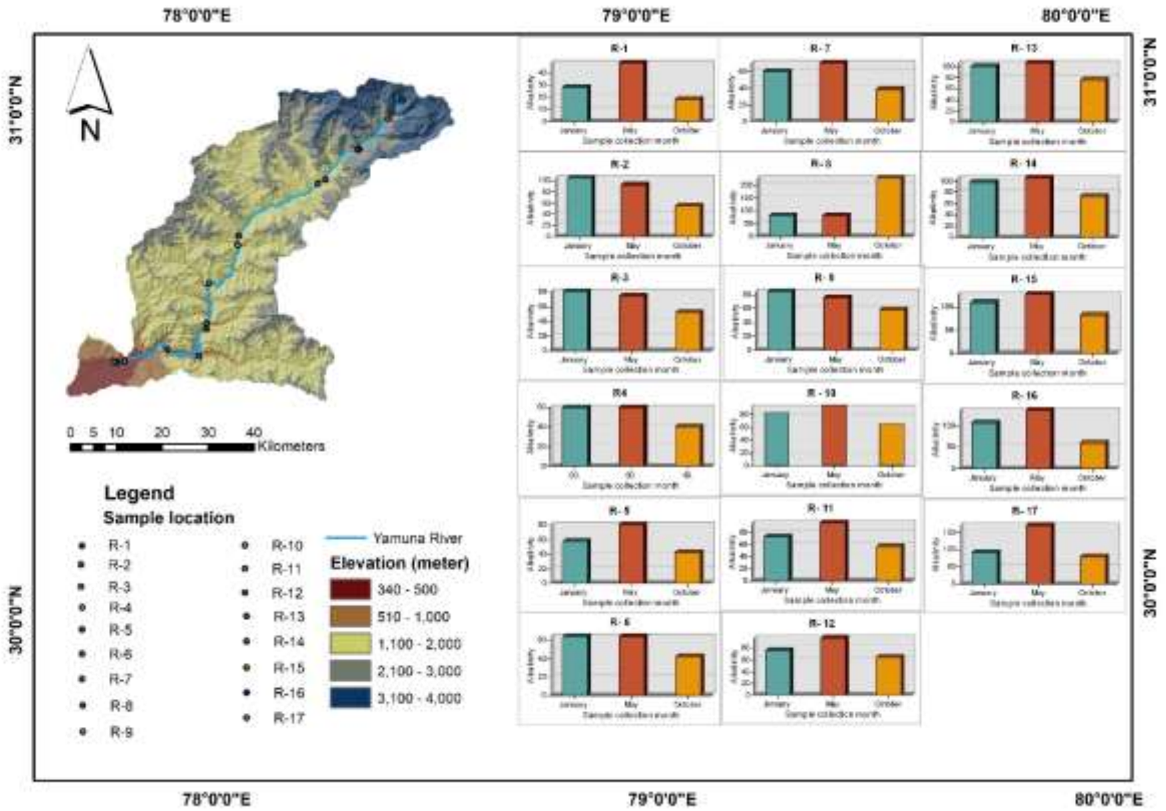
WQI	*Quality*	*Usage*
<25	*Excellent*	*Drinking, Irrigation and Industrial*
26-50	*Good*	*Domestic, Irrigation and Industrial*
51-75	*Fair*	*Irrigation and Industrial*
76-100	*Poor*	*Irrigation*
101-150	*Very Poor*	*Restricted use for irrigation*
>150	*Unfit*	*Require treatment before use.*

Table 3. Sample Collection Month with WQI range.

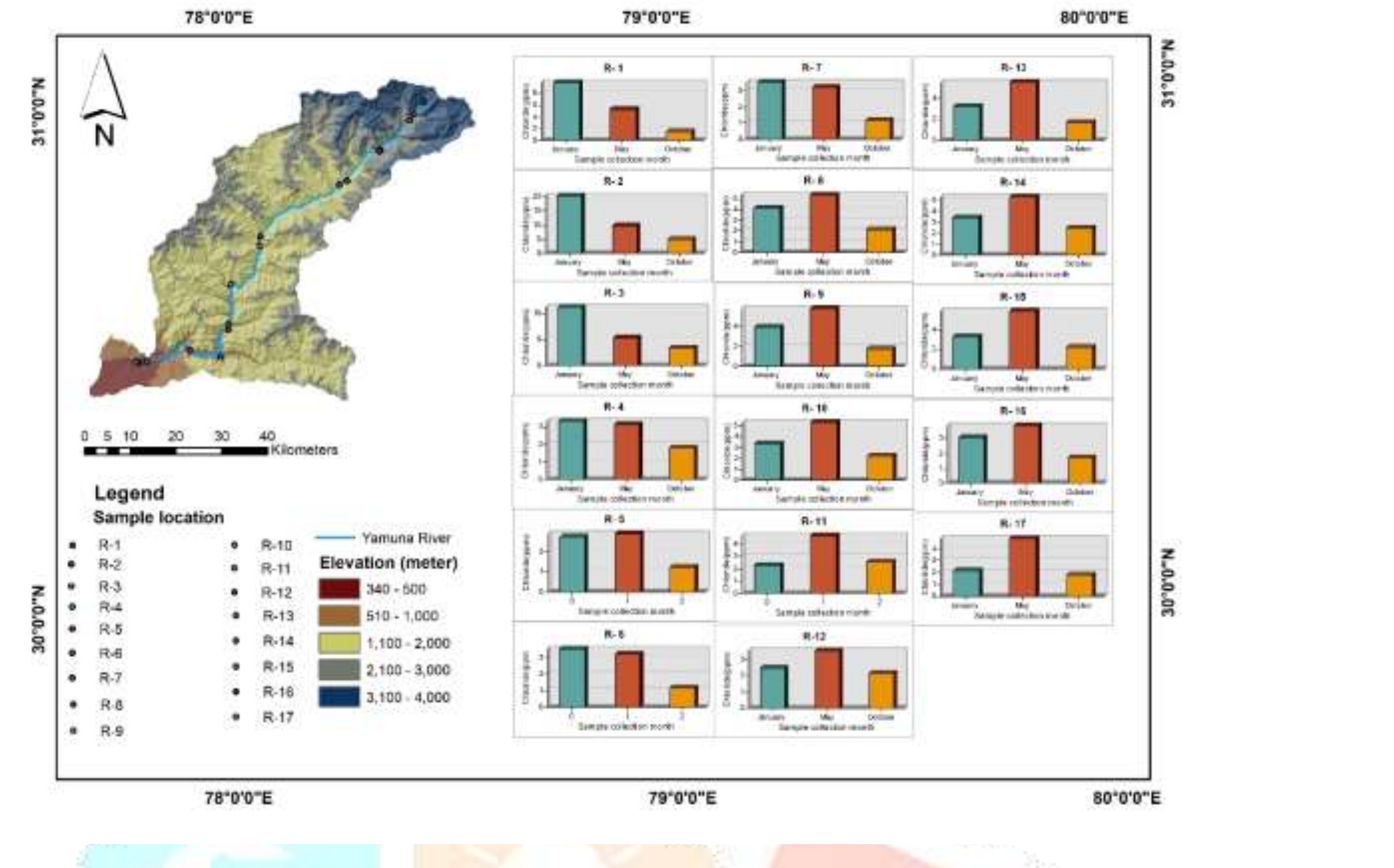
WQI	**Quality**	**January,2022**	**May,2022**	**October,2022**
<25	Excellent	**R4,R5,R7,R8,R9,R10,R11,R12, R13, R15, R16, R17**		**R12**
26-50	Good	**R3, R6, R14**		**R1, R2,R4,R5,R6, R7, R8, R9, R10, R15, R16**
51-75	Fair	**R1, R2**		**R11, R13, R14,R17**
76-100	Poor			
101-150	Very Poor		**R3,R4,R16**	**R3**
>150	Unfit		**R1,R2,R5,R6, R7, R8, R9, R10, R11,R12, R13, R14, R15, R17**	



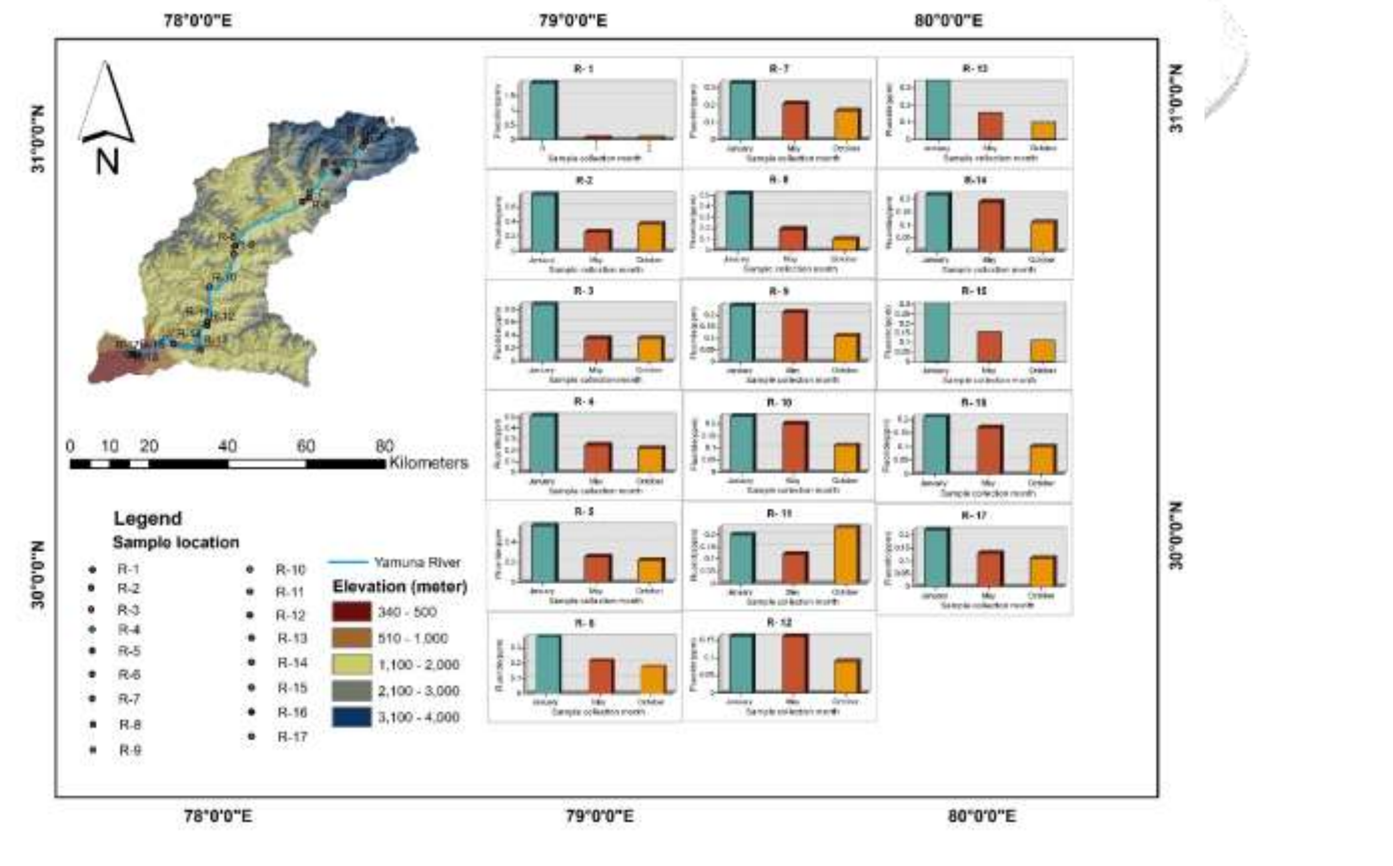
Map1: Study area with sample location.



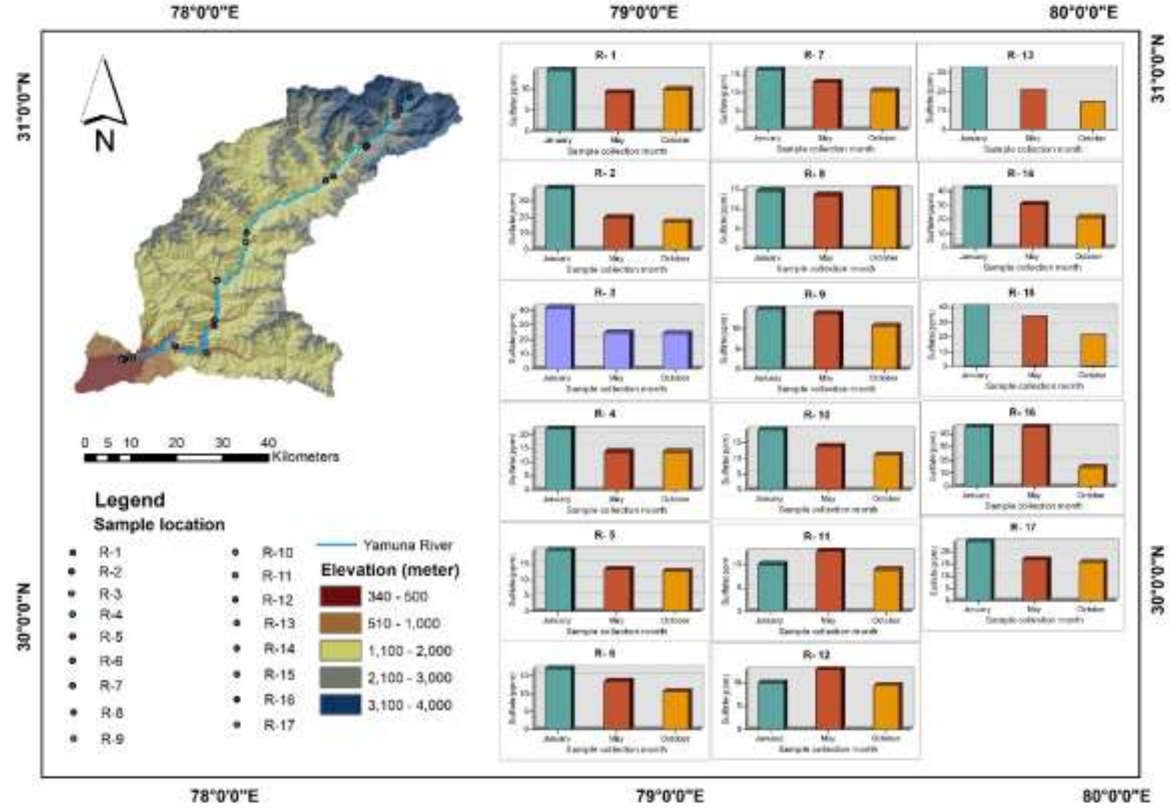
Map2: Alkalinity (ppm)



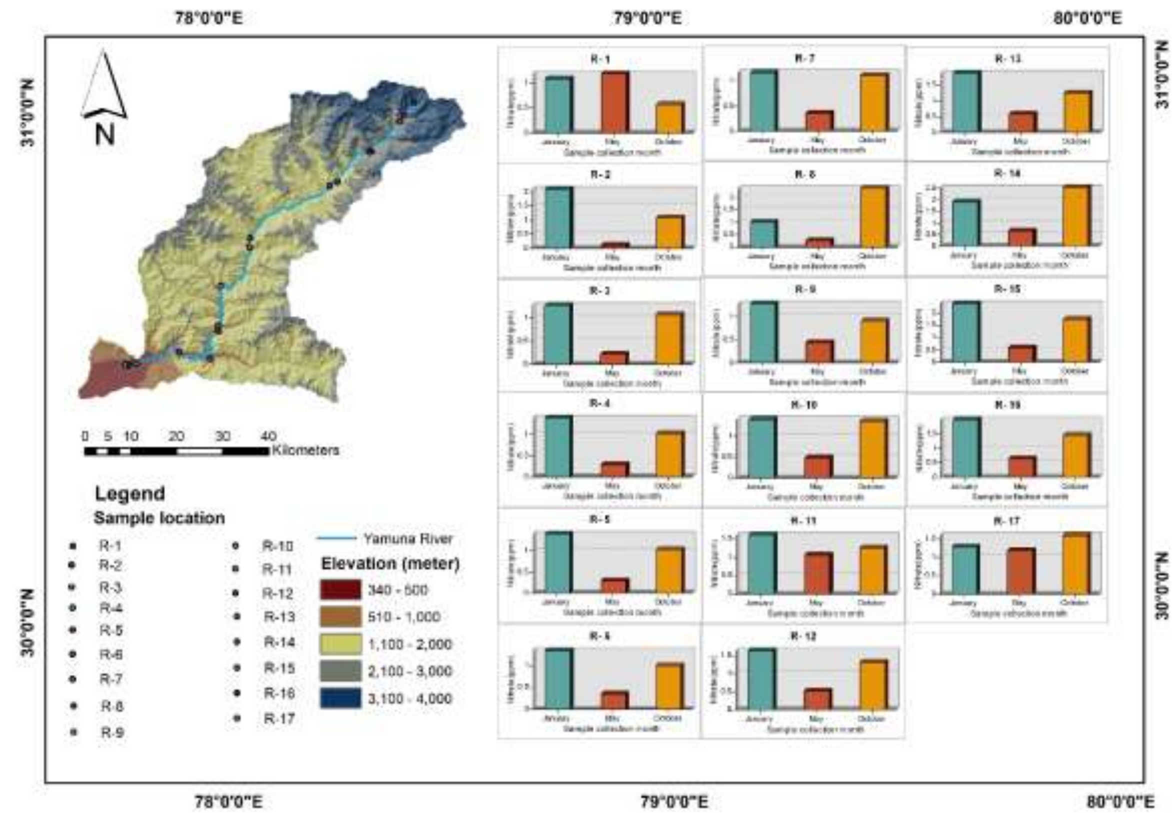
Map3: Chloride (ppm)



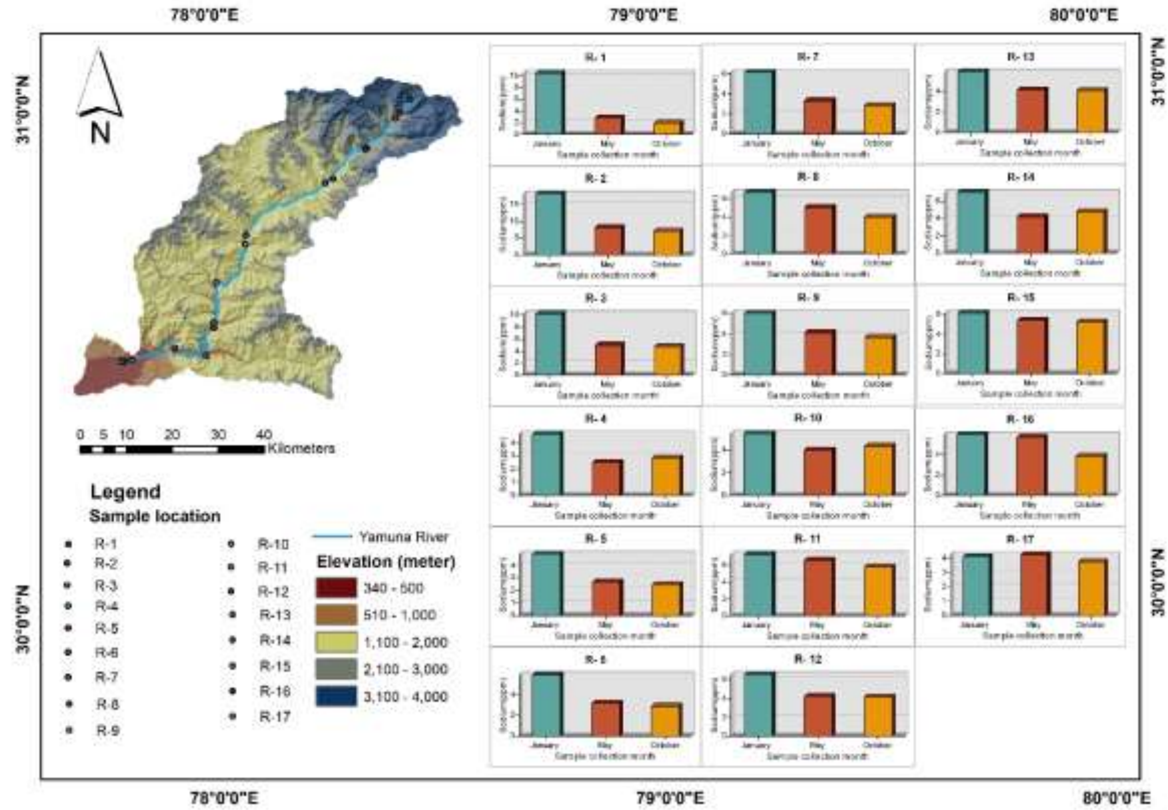
Map4: Fluoride (ppm)



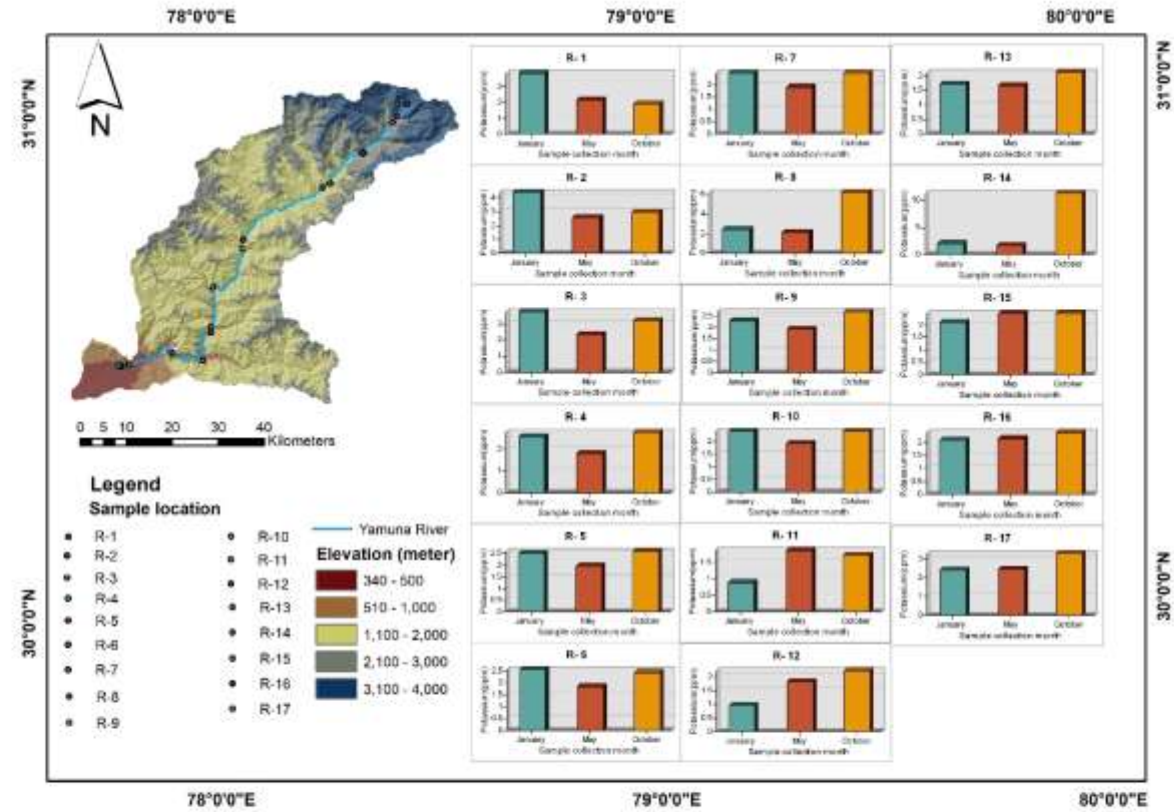
Map5: Sulfate(ppm)



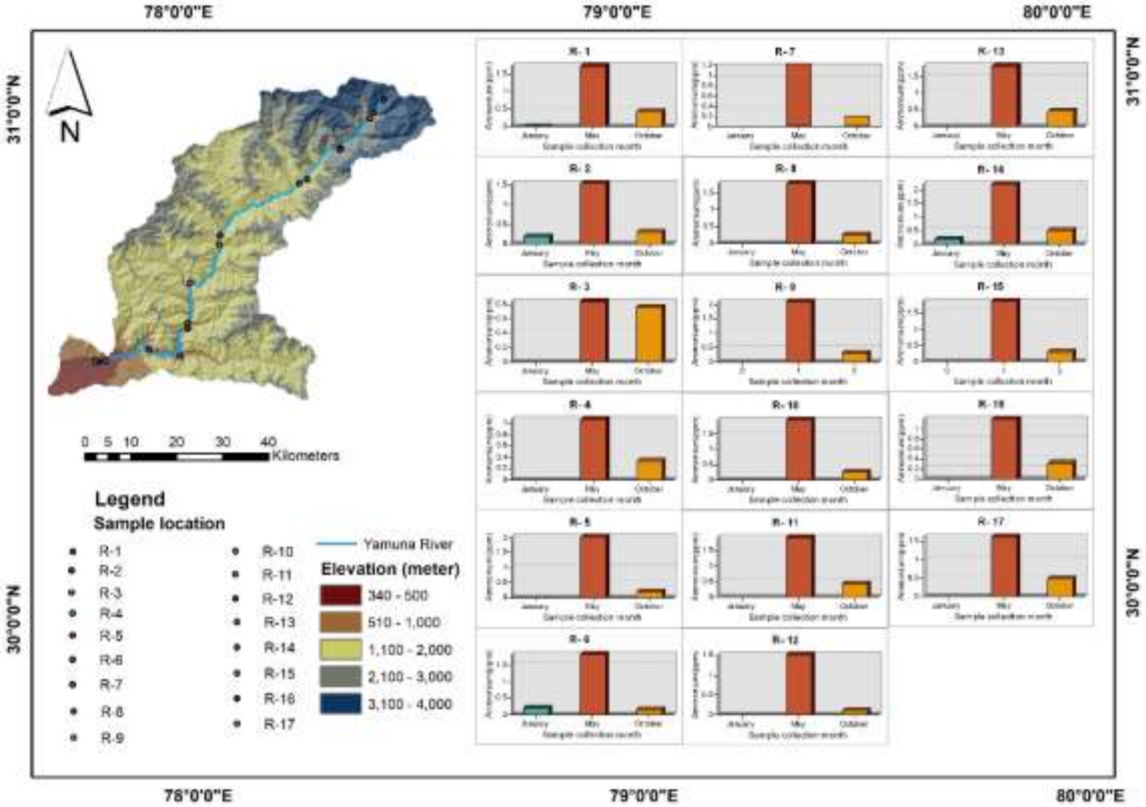
Map6: Nitrate (ppm).



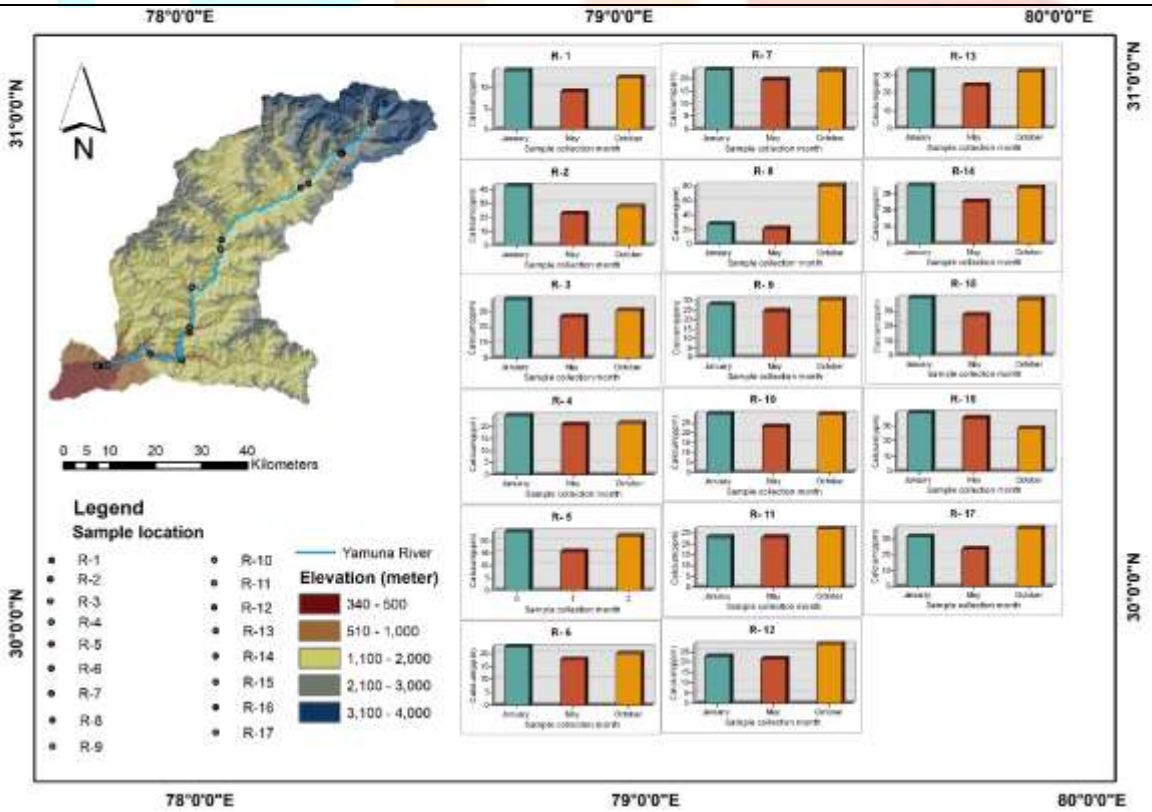
Map7: Sodium (ppm)"



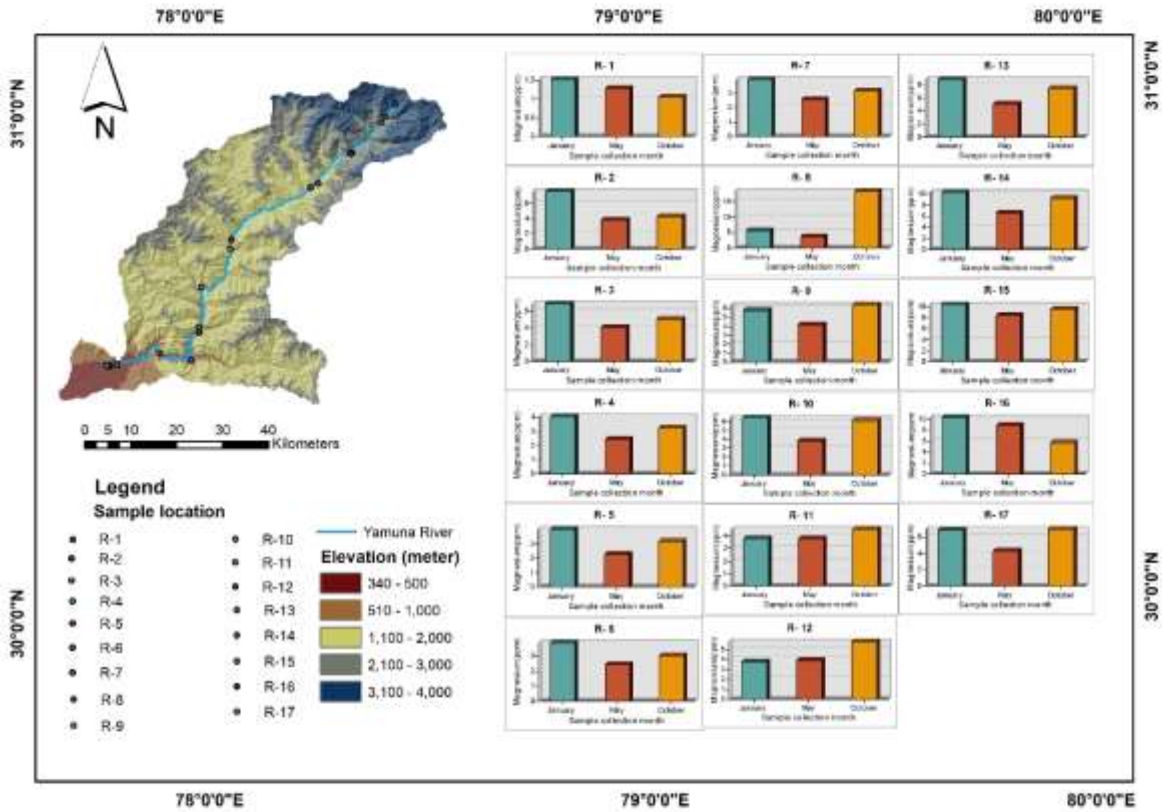
Map8: Potassium(ppm)



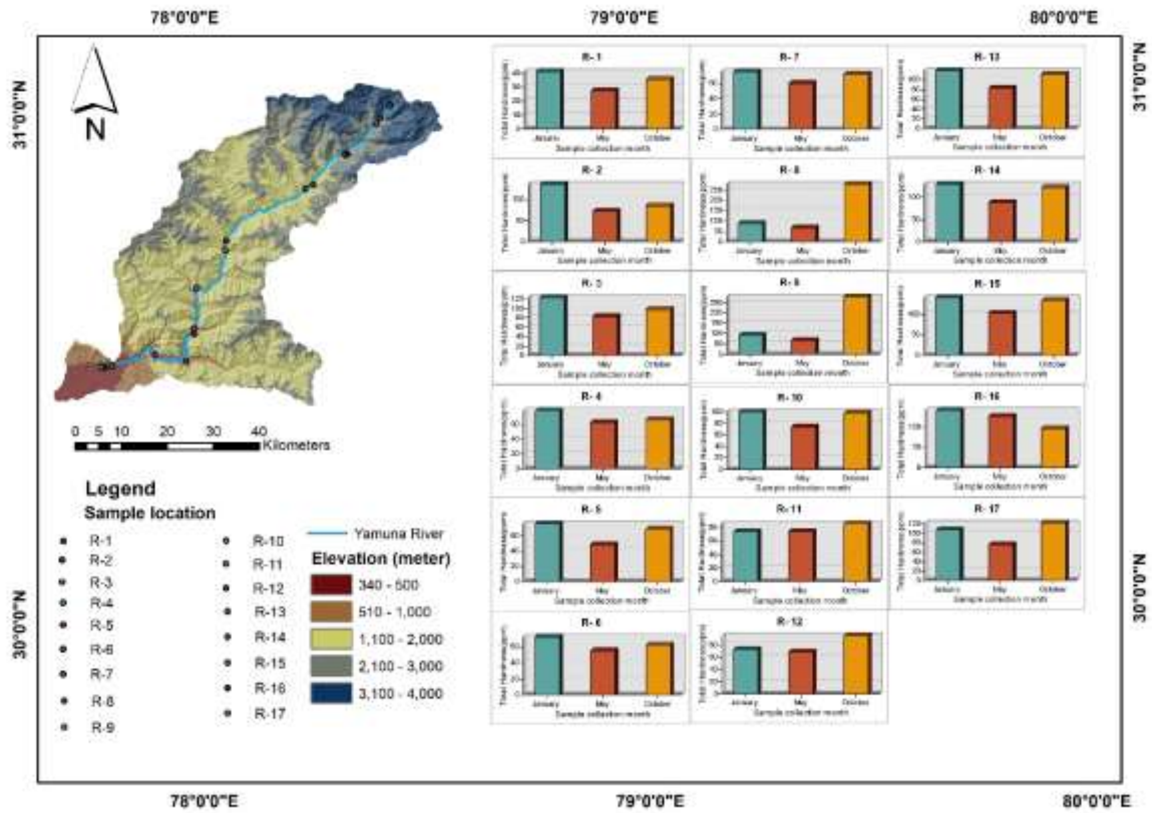
Map9: Ammonium(ppm)



Map10: Calcium(ppm)

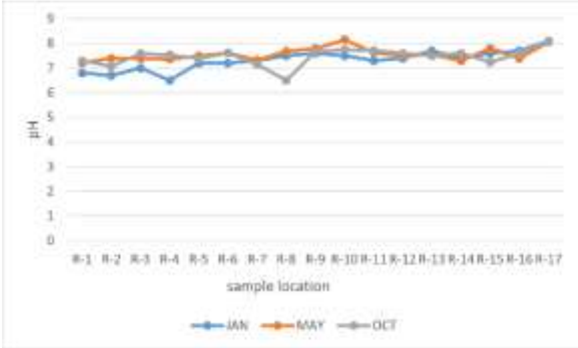


Map11: Magnesium(ppm)

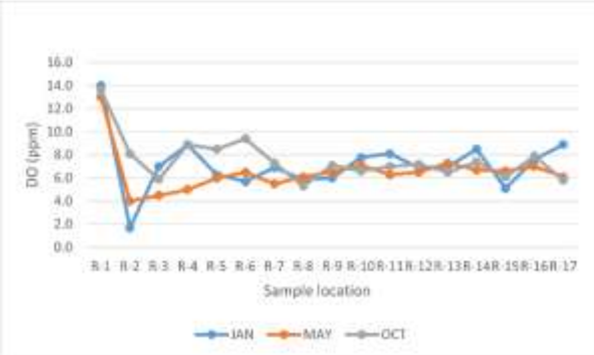


Map12: Total Hardness

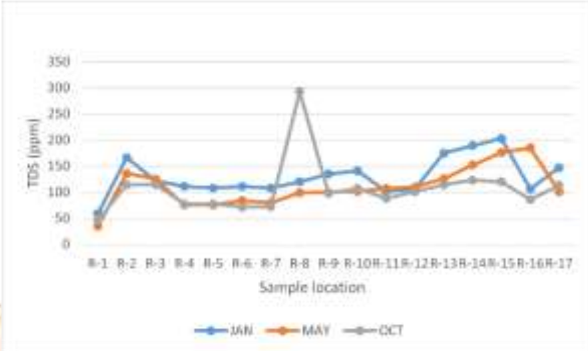
Graph1: Temperature



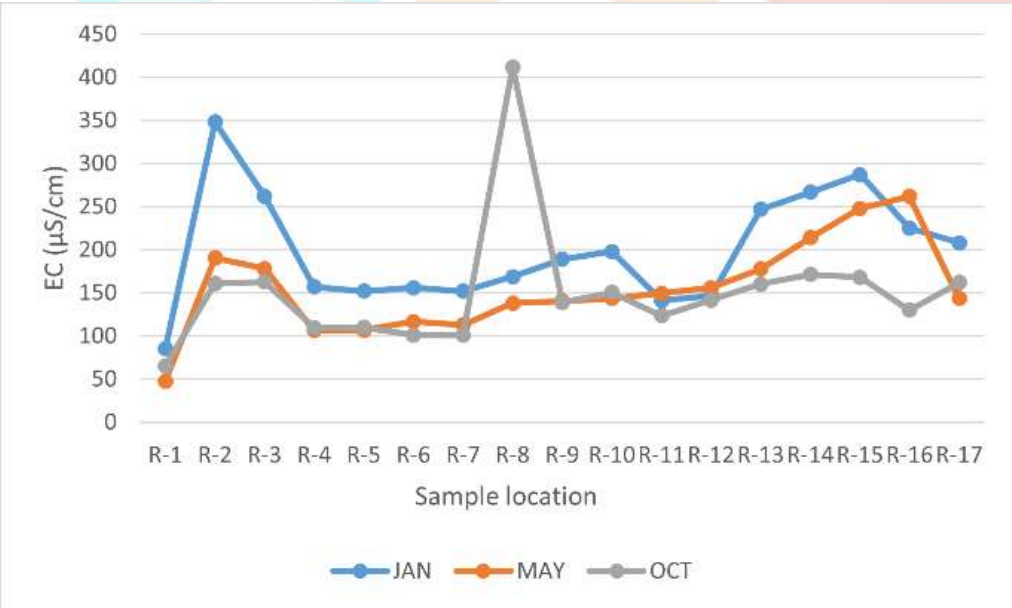
Graph2: pH



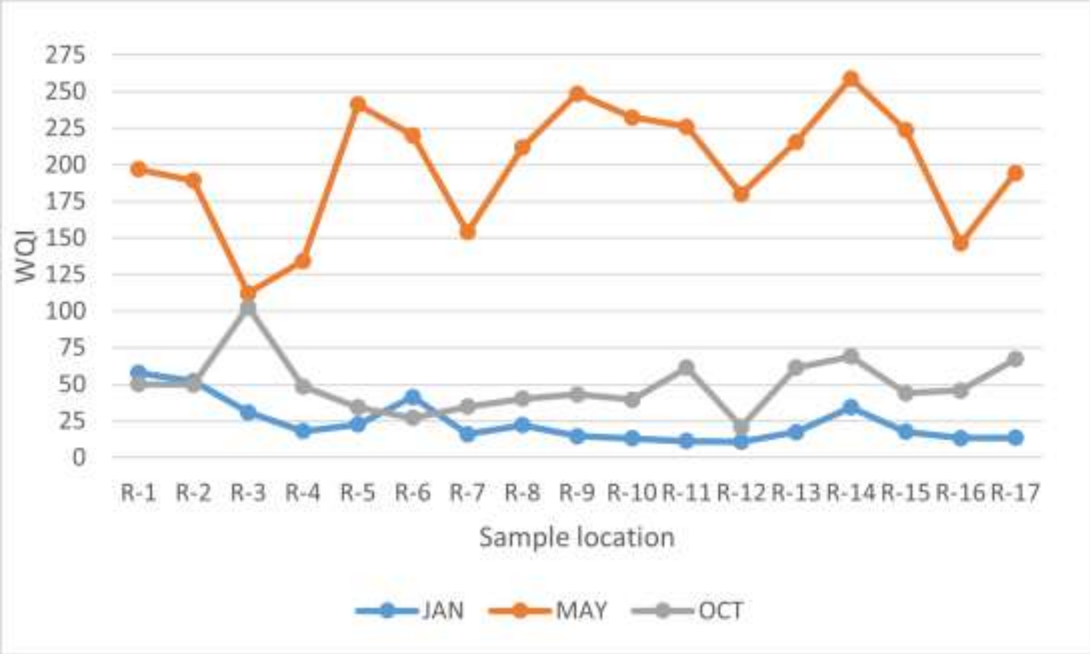
Graph3: DO(Dissolved oxygen)



Graph4: TDS(Total Dissolved solids)



Graph5: EC(Electrical conductivity)



Graph6: Water Quality Index

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