



RESEARCH ARTICLE

PHYSICO-CHEMICAL CHARACTERISTICS OF RIVER ALAKNANDA UTTARAKHAND, INDIA

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ABSTRACT

The present investigation reveals the seasonal changes in concentration of physico-chemical parameters in river Alaknanda in the year 2015-16. Water samples were collected from different sites viz. Vishnu Prayag, Nand Prayag, Karna Prayag and Rudra Prayag of Uttarakhand during summer, monsoon and winter season. The physico-chemical parameters as temperature, pH, dissolved oxygen (DO), biological oxygen demand (BOD), total alkalinity (TA), total hardness (TH), total dissolved solid (TDS), total suspended solids (TSS), total solids, chloride, turbidity and electrical conductivity (EC) were used to analyze the pollution status of river Alaknanda at four selected sites. The results revealed that the Karna Prayag site showed maximum concentration 1.97 ± 0.91 , 83.0 ± 7.55 , 63.33 ± 8.50 , 13.33 ± 3.06 , 252.0 ± 48.5 , 136.3 ± 40.5 of BOD, TH, TA, Turbidity, TS and TSS respectively. The water quality was recorded below the permissible limit setup by United Nation Public Health Services (USPHS) and World Health Organization (WHO). However it may exceed in future with increasing population and anthropogenic interference in the basin and can make ecological imbalance in river flora and fauna.

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INTRODUCTION

Water is the most vital source for sustainability of life. Various geogenic activities (weathering of rocks, erosion, heavy rainfall etc.) and anthropogenic activities (urbanization, agriculture, industrialization, growth of population etc.) are responsible for water pollution, which make it unsuitable for potability (Oluyemi et al., 2010). The river Ganges is regarded as one of the most holy and sacred rivers of the India. It emerges after confluence of main stream of the two important rivers of hills, river Bhagirathi and river Alaknanda at Devprayag. The chemical weathering rate in the Alaknanda river is much higher ($153 \text{ tons km}^{-2} \text{ yr}^{-1}$) compared to the Bhagirathi river ($85 \text{ tons km}^{-2} \text{ yr}^{-1}$). These two parent stream are snow fed and owe their origin to the Himalaya's glaciers known as Gomukh. Ganga after traversing a distance of 2,525 kms fall into the Ganga Sagar (West Bengal) (Sharma et al., 2015). The river is used for drinking, power generation, irrigation, fish production, and religious pilgrimages. It has been under constant threat of pollution by sewage and industrial waste, disposal of dead bodies, deforestation, excessive use of fertilizers and pesticides, bathing and religious pilgrimages. Due entirely to uncontrolled population growth and failure to enact and apply laws prohibiting the discharge of industrial and human waste into

the river, it is becoming dangerously more polluted every day, causing serious health hazards (Omair et al., 2005). Today, over 29 cities, 70 towns and thousands of villages extends along the Ganga banks. Nearly all of their sewage over 1.3 billion liters per day goes directly into the river, along with thousands of animal carcasses, mainly cattle (Pandey et al., 2014). The quality of water is mostly deteriorated by human activities. Now a days, about 42 industries in Uttarakhand state are grossly polluted, out of which, seven industries such as pulp and paper, sugar and distillery etc. disposes the waste directly or indirectly into the river water, which affects the BOD, turbidity and also causes the physico-chemical changes. In the present investigation an attempt has been made to assess the water quality of river Alaknanda at four religious sites of Uttarakhand viz. Vishnu Prayag, Karan Prayag, Nand Prayag and Rudra Prayag. Interpretation of water quality of river Alaknanda via the study of seasonally variation on concentration of physico-chemical parameters such as temperature, pH, dissolved oxygen(DO), biological oxygen demand (BOD), total alkalinity (TA), total hardness(TH) etc.

MATERIALS AND METHODS

Study area: The present study deals with the study of the physico-chemical parameters of Alaknanda river water at four distinct places viz. Vishnu Prayag, Nand Prayag, Karna Prayag

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and Rudra Prayag of Uttarakhand, India. Study sites were shown in the Figure 1.

Sample collection and analysis: The water samples were collected from four sites i.e. Vishnu Prayag, Karna Prayag, Nand Prayag and Rudra Prayag for assess the physico-chemical parameters during three seasons viz. summer, monsoon and winter for the year 2015-2016. Parameters like temperature, pH and dissolved oxygen (DO) were estimated at the spot immediately after the collection of the samples where as water analysis relating to other chemical factors was done in the laboratory which were determined using standard methods (APHA, 2005).

Physico-chemical analysis: The water samples were brought to the laboratory in ice boxes and subjected to the analysis of BOD (by incubating diluted samples at 25° C for 5 days in dark, EC (by conductivity meter), Alkalinity (estimated by titration with standard sulphuric acid using phenolphthalein and methyl orange as indicator), Hardness (estimated by titration with EDTA solution using Erichrome black-T dye as indicator), Chloride (by Mohr's argentometric method using Potassium chromate as indicator), Turbidity (by Nephelometer) and TDS (by Evaporation method).

RESULTS AND DISCUSSION

The physico-chemical characteristics at four sampling sites are appended in Table (1) and Figure 2-13. The water quality analysis of river Alaknanda showed that Karna Prayag Site followed by Rudra Prayag, Nand Prayag and Vishnu Prayag sites was highly polluted due to influx of sewage, domestic, industrial wastes etc.

Temperature: In the present investigation it was noted that temperature were recorded maximum ($15.9^{\circ}\text{C} \pm 4.89$) at Karna Prayag site followed by Rudra Prayag, Nand Prayag and Vishnu Prayag.

pH: pH of an aquatic system is an important indicator of the water quality and the extent pollution in the watershed areas (Kumar *et al.*, 2011). During the study period overall maximum mean pH were recorded at Rudra Prayag (7.90 ± 0.46) in comparison to other sites. There was not much fluctuation recorded in pH values.

Dissolved oxygen (DO): Concentration of dissolved oxygen is one of the most important parameter to indicate water quality and to determine the distribution and abundance of various algal groups. Maximum DO was recorded ($9.80 \text{ mg/l} \pm 0.40$) at Rudra Prayag site in compares to other sites.

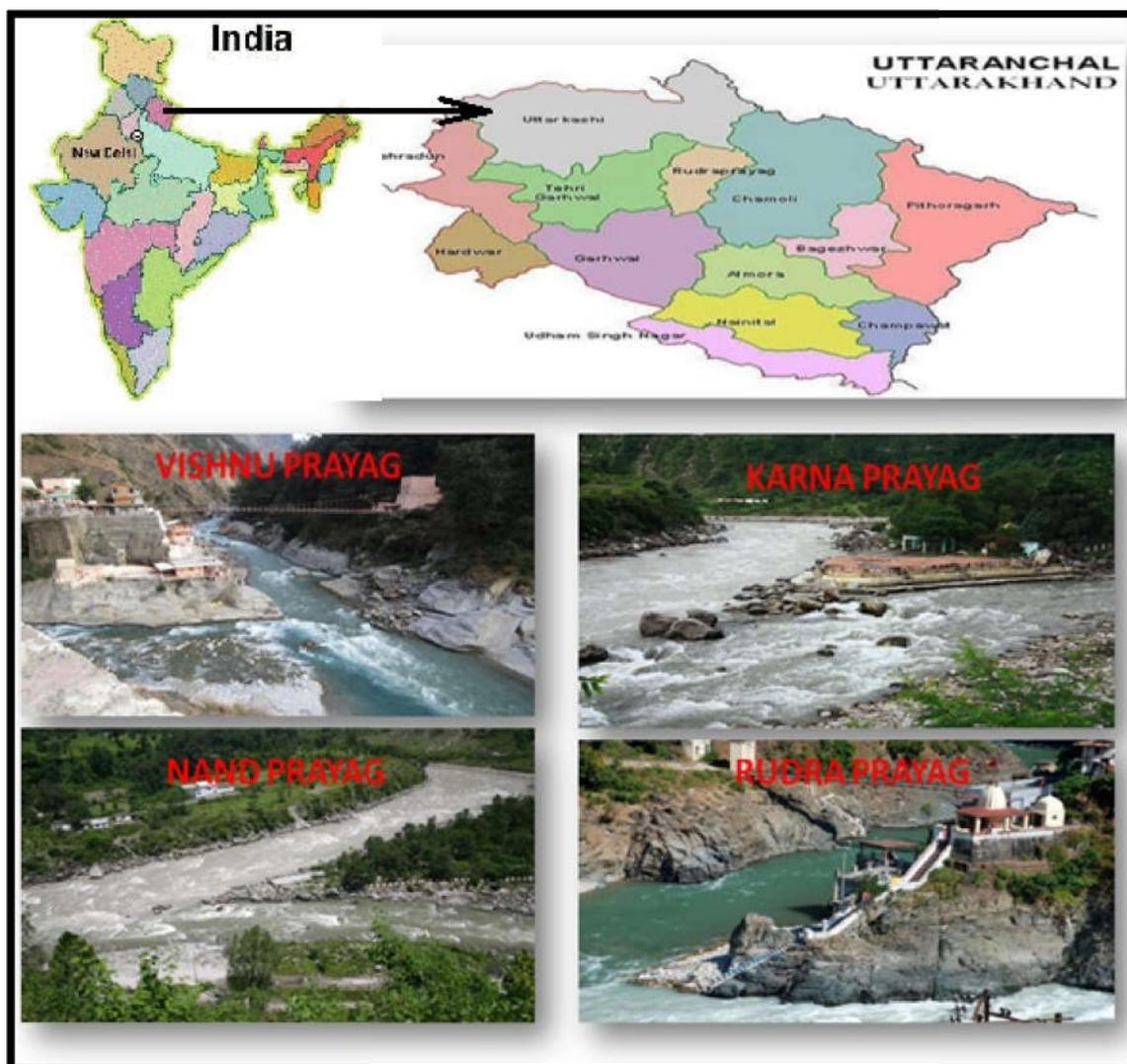
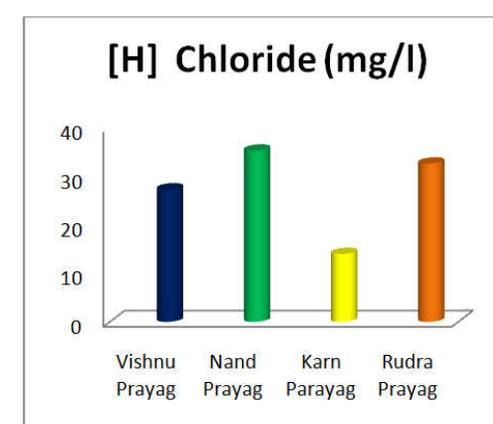
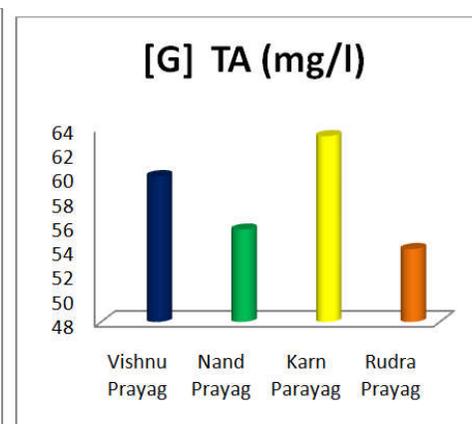
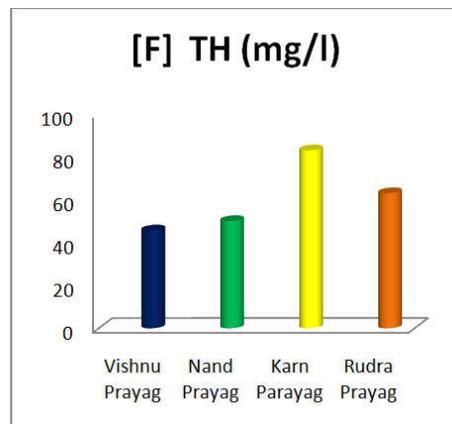
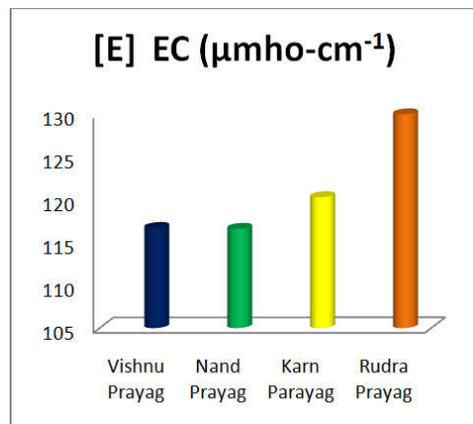
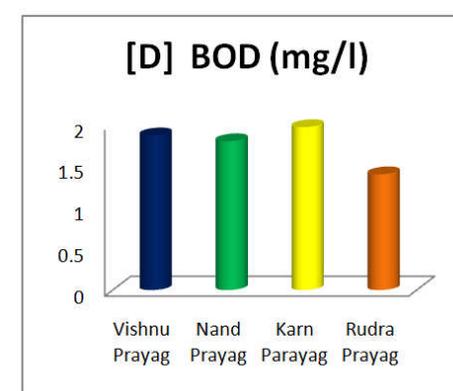
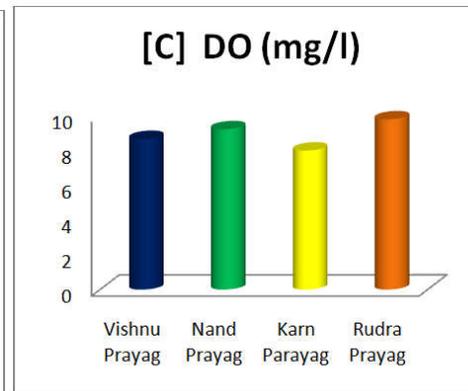
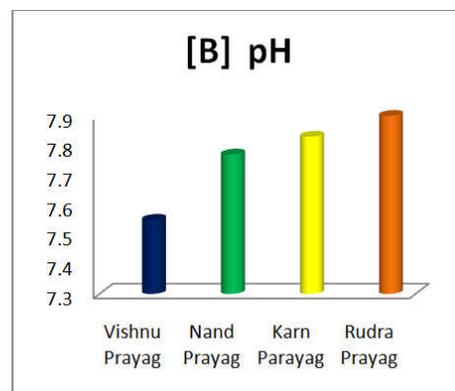
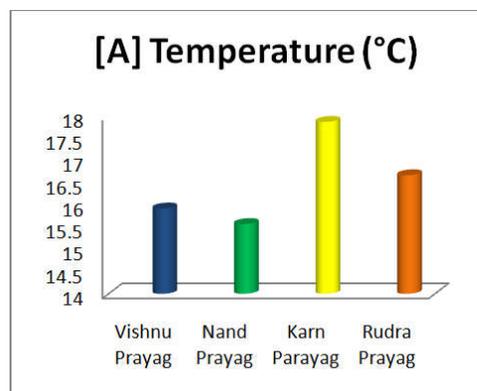


Figure 1. The study sites along the river Alaknanda

Table 1. Physico-chemical estimation of the River Alaknanda at four sites in the year 2014-15

Parameter	Site1: Vishnu Prayag				Site3: Nand Prayag				Site2: Karn Prayag				Site4: Rudra Prayag				Permissible Limit(mg/l)	Standards
	S	R	W	Mean± S.D	S	R	W	Mean± S.D	S	R	W	Mean± S.D	S	R	W	Mean± S.D		
Temp(°C)	17.25	20	10.5	15.9± 4.89	15.7	19.8	11.2	15.57 ±4.30	19.8	24.3	9.5	17.87 ±7.59	16	19	15	16.67±2.08	---	---
pH	7.26	7.8	7.6	7.55 ±0.27	7.8	7.92	7.6	7.8±0.16	7.8	8.2	7.5	7.83 ±0.35	7.5	8.4	7.8	7.90±0.46	6.5-8.5	USPHS
DO(mg/L)	7	8	11	8.67 ±2.08	8	9.2	10.5	9.23±1.25	6.2	7.5	10.3	8.0 ±2.10	10.2	9.4	9.8	9.80±0.40	4.0-6.0	USPHS
BOD(mg/L)	1.9	2.4	1.3	1.87±0.55	1.5	2.1	1.8	1.80±0.30	2.10	2.81	1.0	1.97±0.91	1.2	1.4	1.6	1.40±0.20	5.0	USPHS
EC(µmho-cm ⁻¹)	110	140	100	116.7±20.8	103	149	98	116.6± 28.11	115	152	94	120.3±29.3	120	160	110	130.0± 26.46	300	USPHS
TH(mg/L)	42	60	35	45.67±12.9	50	70	30	50.0±20.0	75	90	84	83.0±7.55	58	70	61	63.0±6.24	500	WHO
TA(mg/L)	68	60	52	60.0±8.0	75	52	40	55.6± 17.79	72	63	55	63.33±8.50	68	49	45	54.00±12.29		
Cl ⁻ (mg/L)	45	22	15	27.33±15.7	57	27	22	35.33±18.93	16	19	7.0	14.00±6.24	33	21	44	32.67±11.50	250	USPHS
TDS(mg/L)	112	95	145	117.13±25.4	114	144	142	133.33±16.77	110	125	112	115.67±8.1	141	189	84	138.0±52.56	500	USPHS
Turbidity(NTU)	7.2	9.8	4.0	7.00 ±2.91	8.5	9.0	5.9	7.80±1.66	10	16	14	13.33±3.06	7.8	11.2	6.8	8.60±2.31	---	---
TS	122	270	152	181.3±78.2	122	334	154	203.3±114.29	226	308	222	252.0±48.5	153	388	93	211.3±155.91	---	---
TSS	108	175	93	64.0±96.14	8	190	12	70.0±103.94	116	183	110	136.3±40.5	12	199	9	73.3±108.84	---	---



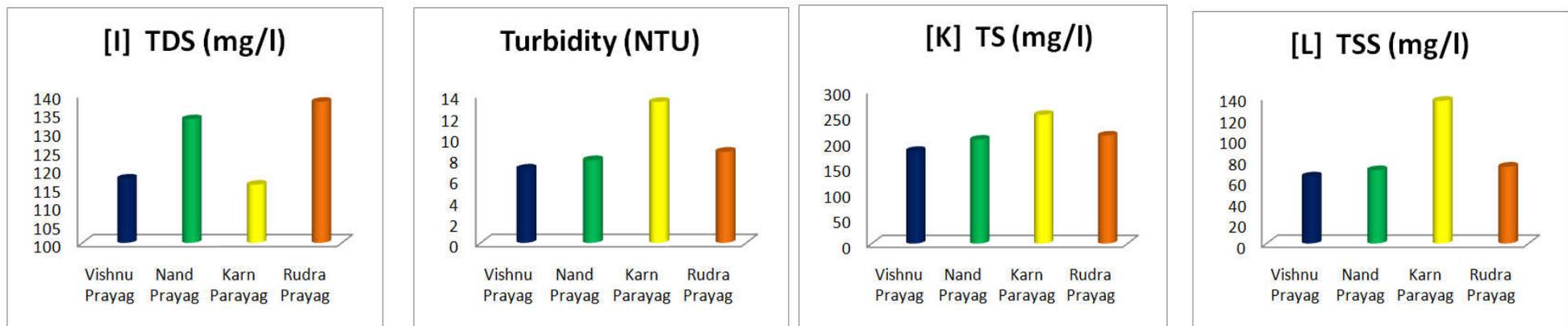


Figure 2. Graphs showing average variations in various physico-chemical parameters (A to L) at four sites viz. Vishnu Prayag, Nand Prayag, Karna Prayag, and Rudra Prayag.

Biological oxygen demand (BOD): BOD is the quantity of oxygen required by bacteria and other microorganisms during the biochemical degradation and transformation of organic matter present in wastewater under the aerobic condition. It is a valuable parameter for assess of water quality. The present investigation revealed that Karna Prayag site has the highest concentration of BOD ($1.97 \text{ mg/l} \pm 0.91$) in compares to other sites viz. Rudra Prayag, Nand Prayag and Vishnu Prayag.

Electrical Conductivity (EC): It represents the total concentration of soluble salts/mineral salts in water (Trivedi et al., 1986), thereby making it sour and unsuitable for drinking. Present results shown that Karna Prayag site has maximum values of EC ($120.3 \mu\text{mho-cm}^{-1} \pm 29.3$) in compares to other sites viz. Rudra Prayag, Nand Prayag and Vishnu Prayag. There was not much fluctuation recorded in EC values.

Turbidity: The turbidity is a striking characteristics to know the physical status of the rivers. The suspended particles, discharged effluents, soil particles, decomposed organic matters, total dissolved solids as well as the microscopic organisms increase the turbidity of water, which interferes with the penetration of light. Maximum turbidity were recorded at Karna Prayag ($13.33 \text{ NTU} \pm 3.06$) in compare to other sites viz. Rudra Prayag, Nand Prayag and Vishnu Prayag.

Total Hardness: Calcium and magnesium are the component of Total Hardness. It is present in the form of carbonate and bicarbonate. Water with less than 75 mg/l of CaCO_3 is considered soft and above 75 mg/l of CaCO_3 as hard (Sharma et al., 2015). It is an important criterion for determining the usability of water for domestic, drinking and many industrial supplies (Mitharwal et al., 2009). The present study revealed that maximum hardness were recorded ($83.0 \text{ mg/l} \pm 7.55$) at Karna Prayag followed by Rudra Prayag, Nand Prayag and Vishnu Prayag sites.

Total Alkalinity : It is quantitative capacity of water sample to neutralize a strong acid to a pH. Increase dilution of river water may be responsible for lower values of alkalinity in rainy seasons (Pandey et al., 2014). The present investigation revealed that Karna Prayag site contains maximum alkalinity values ($63.33 \text{ mg/l} \pm 8.50$) followed by Vishnu Prayag, Nand Prayag and Rudra Prayag. The high value of alkalinity indicates the presence of weak and strong base such as carbonates, bicarbonates and hydroxides in the water body. (Abassi et al., 1999)

Chloride : Chloride ion is one of the major anions found in water and are generally combined with calcium, magnesium or sodium. Chlorides are leached from various rocks into soil and ground water by weathering. The chloride ion is highly mobile and is transported to closed basins. Present investigation revealed that chloride ion maximum found at Nand Prayag ($35.33 \text{ mg/l} \pm 18.93$) site followed by Rudra Prayag, Vishnu Prayag and Karna Prayag.

Total dissolved solid (TDS): TDS is measure of the combined content of all organic and inorganic substances contained in liquid in molecular, ionized or micro- granular suspended form. It is an important parameter for water quality. Results shown that Rudra Prayag site contains maximum TDS ($138.0 \text{ mg/l} \pm 52.56$) due to the huge discharges of industrial effluents without or partial pre-treatment.

Total suspended solid (TSS): In the present investigation it was noticed that the total suspended solids were maximum at Karna Prayag site ($136.3 \text{ mg/l} \pm 40.5$) followed by Rudra Prayag ($73.3 \text{ mg/l} \pm 108.84$), Nand Prayag ($70.0 \text{ mg/l} \pm 103.94$) and Vishnu Prayag ($64.0 \text{ mg/l} \pm 96.14$).

Total solids (TS): Total solids are simply summation of total dissolved solids and total suspended solids present in the water. In the present investigation it was noted that the total solids were maximum at Karna Prayag site (252.0 mg/l \pm 48.5) followed by Rudra Prayag (211.3 mg/l \pm 155.91), Nand Prayag (203.3 mg/l \pm 114.29) and Vishnu Prayag (181.3 mg/l \pm 78.2).

Conclusion

The present investigations conclude that the quality of water samples subjected to study was acceptable according to the permissible limit set up by USPHS and WHO for most of the considering physico-chemical parameters. Total hardness at four sites viz. Karna Prayag, Vishnu Prayag, Nand Prayag and Rudra Prayag sites along the river Alaknanda was found highest in compared to other sites. The river Alaknanda at Karna Prayag in Uttarakhand was most polluted despite being a quite popular tourist place. Finally it can say that the water quality was recorded below the permissible limit setup by United Nation Public Health Services (USPHS) and World Health Organization (WHO). However it may exceed in future with increasing population and anthropogenic interference in the basin and can make ecological imbalance in river flora and fauna.

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