Temporal Fluctuations in Physicochemical Characteristics of the Kosi River with in the Kumaon Region, Uttarakhand

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Abstract
This study investigates the intricate dynamics of water quality in the Kosi River, located in Kumaon, Uttarakhand, over the period spanning May 2021 to April 2022. An extensive analysis of key parameters, including nitrate, phosphate, total hardness, total dissolved solids (TDS), and alkalinity, was conducted. Seasonal variations were observed, with peak concentrations of nitrate and phosphate occurring during spring, attributed to heightened phytoplanktonic activity. Conversely, total hardness and alkalinity exhibited an increase during winter months. Despite these fluctuations, the study asserts the river's sustained suitability for aquatic life, particularly fishes, with water quality categorized as moderate. Noteworthy is the absence of pollution in the Kosi River, as all measured parameters consistently adhere to permissible limits outlined by established water quality standards. This research provides valuable insights into the complex dynamics shaping riverine ecosystems, underlining the necessity for continuous monitoring and conservation efforts to preserve the ecological equilibrium of freshwater habitats like the Kosi River.

Keywords- water quality dynamics, Kosi River, Seasonal variation, Kumaon region Uttarakhand.

1. Introduction: -

Currently, global**: -** concerns about escalating water pollution pervade as numerous water bodies, encompassing rivers, lakes, groundwater reservoirs, springs, and oceans, undergo continual deterioration, resulting in compromised water quality. This degradation poses significant threats to both human health and aquatic ecosystems, precipitating a surge in waterborne illnesses annually and a steady decline in aquatic biodiversity. The introduction of pollutant substances alters the physicochemical and organic composition of water, exacerbating health risks and disrupting aquatic life (khatum,2017). Particularly in developing nations, water pollution emerges as a formidable challenge, with pollution typically originating at the water source and propagating to adversely affect local communities through waterborne diseases (Gambo et al., 2018). Main culprits contributing to water pollution include untreated sewage discharges, industrial effluents, and agricultural runoff, with approximately 1500 pollutants identified as hazardous to freshwater ecosystems. The consumption of contaminated water not only compromises health but also disrupts bodily functions (Dwivedi, 2017). Water pollution is bifurcated into two primary categories based on its source: point pollution, emanating from identifiable sources, and non-point source pollution, originating from diffuse and indeterminate origins (WMO, 2012). Studies conducted by Singh and Gupta

(2017) delineate two broad classifications of pollutants—organic and inorganic. Haseena et al. (2017) study the impact of polluted water on human health, highlighting three prevalent waterborne diseases: bacterial, viral, and parasitic. Owa (2014) explores the causative factors and management strategies for water pollution, advocating for pollution prevention and waste minimization approaches as effective mitigation measures. Shelakoti (2016) conducts an analysis of the physicochemical attributes of the Kosi River in Almora district, aimed at assessing the potability of its water. Traditionally revered as clean and safe for domestic use in the Himalayan Mountains, the Kosi River has become increasingly contaminated due to indiscriminate human activities. This study aims to scrutinize the physicochemical and bacteriological parameters of raw water from the Kosi River, which serves as the primary drinking water source for Kumaun region and over hundreds of surrounding villages.

1.1 Study area-: The Kosi watershed, nestled in the Central Himalayan region within Almora district, Uttarakhand, spans latitudes from 29°33'47'' N to 29°52'20'' N and longitudes from 79°33'12'' E to 79°48'11'' E, encompassing an area of 463.45 km². Originating from the Rudradhari spring source in Almora district, Kumaun division, Uttarakhand, the Kosi River emerges as a significant tributary of the revered Ganga River. Its catchment area extends over 3,420 sq km, with a total length spanning 240 km. During the study period, four primary sites – Betalghat, Mohan, Ramnagar, and Sultanpur – were meticulously selected for investigation, with Sultanpur marking the culmination point of the Kosi River before merging with Uttar Pradesh. The Kosi River serves diverse purposes, including drinking, washing, bathing, fishing, and the disposal of various wastes, encompassing solid waste, domestic waste, industrial waste, and cremation waste. The study aims to analyze seasonal fluctuations in the water quality of the Kosi River in the Kumaon Himalayas and to assess traditional water harvesting practices employed by indigenous communities in the Kumaon region. By evaluating both seasonal variations in key physicochemical parameters and the role of local water management systems in daily use, this research seeks to deepen understanding of sustainable water resource utilization and conservation strategies developed by the region's indigenous populations.

Site 1- Betalghat
Site2-Mohan
Site 3- Ramnagar
Site 4- Sultanpur patti

Table.1 Location of sites from where samples have been collected

S.N	Longitude	Latitude	Locality name
1	79.306517	29.5589	Betalgaht
2	79.14725	29.48219	Mohan
3	79.132804	29.399325	Ramnagar
4	79.039963	29.1161	Sultanpurpatti

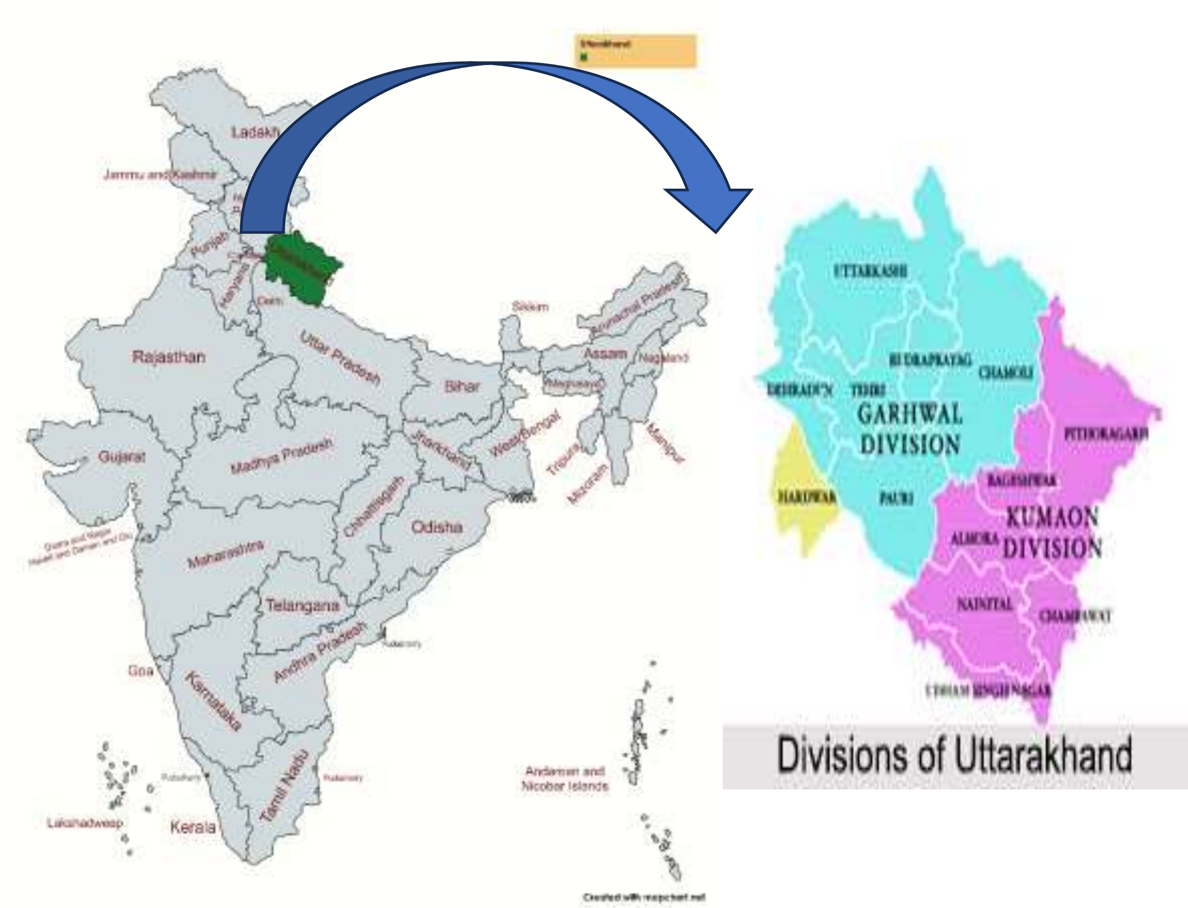


Fig.1

Location Map showing the four Sampling sites, Betalgaht (S1), Mohan(S2),Ramnagar(S3), Sultanpurpatti(S4) in the Kosi River of Kumaun Himalaya.

2. Material & Method

2.1 Sampling - Four sampling sites (S1-S4) were carefully chosen based on considerations of geographical location, environmental characteristics, and land use practices. The precise locations of these sampling sites are depicted in Figure 1 and summarized in Table 1.

Water samples were systematically collected from these sites and stored in sterilized 500 mL bottles in accordance with the standard protocols outlined by the American Public Health Association (APHA). Sampling activities were conducted from May 2020 to 2021 to capture seasonal variations in river water quality. Concurrently, water temperature readings were recorded at the time of sampling. The study period was divided into distinct seasons: the pre-monsoon season (PRM) spanning from March to May, the monsoon season (MON) covering June to September, and the post-monsoon season (POM) occurring from October to December. These delineations were based on the historical rainfall patterns observed in the region during these months. Laboratory analyses were then conducted to assess twelve physicochemical parameters, including Water temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), alkalinity, nitrate, chloride, dissolved oxygen (DO), Phosphate, calcium, and total coliform count. These analyses were performed in accordance with established guidelines to ensure accuracy and consistency in the measurement of water quality parameters.

2.2 Analytical Methods and Laboratory Analysis:

Critical parameters for water quality evaluation, such as pH, dissolved oxygen, and Temperature, were meticulously assessed at each sampling location using specialized field instruments. The pH meter determined the acidity or alkalinity of water samples, while the Dissolved Oxygen (D.O.) meter quantified dissolved oxygen levels. Additionally, the use of a G.P.S. Device facilitated accurate spatial documentation by precisely recording coordinates and sampling point locations. Laboratory analysis was employed to scrutinize specific parameters essential for comprehensive water quality assessment. Hardness, nitrate, chloride, Phosphate, Chloride, DO, Alkalinity, Total Dissolved Solids (T.D.S.), and total coliform underwent rigorous examination, providing detailed insights into water quality characteristics across the study area. Through meticulous laboratory-based assessments, a comprehensive understanding of water quality parameters was achieved, enhancing the overall characterization of water quality dynamics within the study area.

Table-2

Monthly Variation in Physico-chemical parameter of Kosi River at sampling site-1 (Betalghat) during 2021-2022

SN	Parameter Monthly	pH	Temp	EC	TDS	Alkalinity	Chloride	Calcium	DO	Hardness	Nitrate	Phosphate	TC
1			°C	ꭒs/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	MPN
2	May-21	7.32	17° C	260	127	172	24	107	7.2	202	0.04	0.18	350
3	Jun-21	8.11	20.2 °C	292	155	162	19	136	8.2	220	0.11	0.45	240

4	Jul-22	7.52	19°C	210	167	152	15	118	9	248	0.09	0.23	345
5	Aug-21	7.96	18°C	270	183	182	25	119	7.2	258	0.02	0.16	350
6	Sep-21	7.95	18.5°C	290	195	175	27	152	7.4	224	0.06	0.95	220
7	Oct-21	7.31	17°C	287	187	172	21	132	8.6	234	0.08	0.13	170
8	Nov-21	7.89	15°C	270	173	166	25	122	8.5	235	0.05	0.32	150
9	Dec-21	7.76	14°C	230	183	154	21	134	7.8	232	0.02	0.45	150
10	Jan-22	7.35	10°C	230	166	168	17	126	8.2	234	0.08	0.27	130
11	Feb-22	7.72	10°C	210	174	172	14	136	8.6	226	0.07	0.49	150
12	Mar-22	7.66	11°C	220	153	184	23	128	8	240	0.06	0.38	170
13	Apr-22	7.15	17°C	210	143	176	19	126	8.6	218	0.1	0.11	210

Table-3

Monthly Variation in Physico-chemical parameter of Kosi River at sampling site-2(Mohan) during 2021-2022

SN	Parameter monthly	pH	Temp	EC	TDS	Alkalinity	Chloride	Calcium	DO	Hardness	Nitrate	Phosphate	TC
1			°C	ɥs/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	MPN
2	May-21	8.2	19°C	210	130	145	13	172	5.9	212	0.03	0.17	240
3	Jun-21	7.4	22°C	244	145	132	22	162	6.2	245	0.05	0.18	210
4	Jul-22	7.32	24°C	235	162	128	44	174	5.4	218	0.04	0.16	245
5	Aug-21	8.25	24.9°C	210	172	112	36	162	5.6	245	0.07	0.17	280
6	Sep-21	8.1	24.7°C	212	140	90	42	192	5.9	282	0.04	0.15	210
7	Oct-21	7.9	25°C	280	162	115	40	182	6.5	206	0.06	0.18	170
8	Nov-21	8.5	21.9°C	250	155	122	29	192	7.8	209	0.05	0.12	145

9	Dec-21	8.2	19°C	220	127	119	38	185	7.2	215	0.05	0.21	162
10	Jan-22	7.32	14°C	212	140	154	29.3	162	4.3	192	0.06	0.15	210
11	Feb-22	7.42	14°C	217	145	140	23.53	118	4.6	154	0.04	0.13	150
12	Mar-22	7.9	15°C	167	132	130	29.8	121	4.3	157	0.08	0.17	171
13	Apr-22	8.1	23°C	174	119.3	87	32	140	6.9	159	0.07	0.16	175

Table-4

Monthly Variation in Physico-chemical parameter of Kosi River at sampling site-3 (Ramnagar) during 2021-2022

S.N	**Parameter monthly**	**pH**	**Temp**	**EC**	**TDS**	**Alkalinity**	**Chloride**	**Calcium**	**DO**	**Hardness**	**Nitrate**	**Phosphate**	**TC**
1			°C	ʯs/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	MPN
2	May-21	7.65	19°C	198	137	156	23	114	7.1	206	0.04	0.14	210
3	Jun-21	7.91	21°C	234	155	167	19	128	6	234	0.002	0.19	340
4	Jul-22	7.28	23°C	145	167	184	17	132	6.2	246	0.02	0.25	210
5	Aug-21	8.14	21°C	129	183	192	19	128	7.23	234	0.02	0.19	240
6	Sep-21	7.91	18°C	143	195	188	15	128	7.24	226	0.03	0.16	350
7	Oct-21	7.49	16°C	141	187	188	21	118	7.32	220	0.08	0.15	280
8	Nov-21	7.32	15°C	189	173	184	17	112	7.49	238	0.07	0.17	220
9	Dec-21	7.43	13°C	270	183	185	16	113	7.1	216	0.09	0.23	210
10	Jan-22	7.65	13°C	243	187	176	21	126	8	234	0.06	0.13	150
11	Feb-22	7.58	14°C	230	192	182	13	136	8.2	248	0.003	0.11	170
12	Mar-22	7.79	13°C	280	176	188	19	128	8	240	0.002	0.33	140
13	Apr-22	7.67	18°C	260	197	182	17	126	8.6	238	0.08	0.18	130

Table-5

Monthly Variation in Physico-chemical parameter of Kosi River at sampling site-4 Sultanpurpatti) during 2021-2022

S. N	**Parameter monthly**	**pH**	**Tempe**	**EC**	**TDS**	**Alkalinity**	**Cl-**	**Calcium**	**DO**	**Hardness**	**Nitrate**	**Phosphate**	**TC**
1			°C	µs/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	MPN
2	May-21	7.2	24°C	612	345	172	24	82	6.7	202	0.04	0.11	132
3	Jun-21	7.43	32°C	619	413	162	19	86	4	220	0.11	0.12	440
4	Jul-22	7.3	29°C	710	467	152	15	76.95	4.5	248	0.09	0.35	210
5	Aug-21	7.4	22°C	697	455	182	25	71.45	6.6	258	0.02	0.12	245
6	Sep-21	7.52	20°C	689	460	175	27	72.78	6.8	224	0.06	0.08	350
7	Oct-21	7.2	21°C	600	396	172	21	68.86	5.2	234	0.08	0.12	280
8	Nov-21	7.1	23°C	582	394	166	25	72	6.1	235	0.05	0.11	170
9	Dec-21	7.42	17°C	562	376	154	21	71	6.5	232	0.02	0.15	150
10	Jan-22	7.9	18°C	410	277	168	17	95.2	7	234	0.08	0.25	130
11	Feb-22	7.2	22°C	260	174	172	14	86.2	7.2	226	0.07	0.26	150
12	Mar-22	7.6	25°C	300	210	184	23	87	6.1	240	0.06	0.12	140
13	Apr-22	7.7	28°C	345	210	176	19	86	6.7	218	0.11	0.11	150

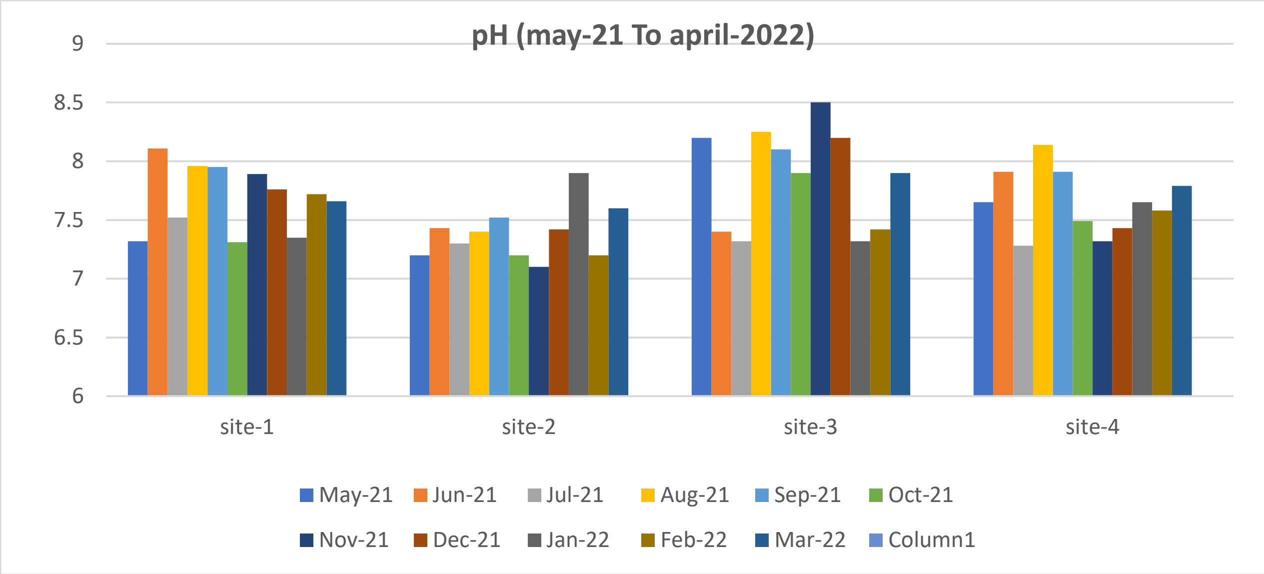
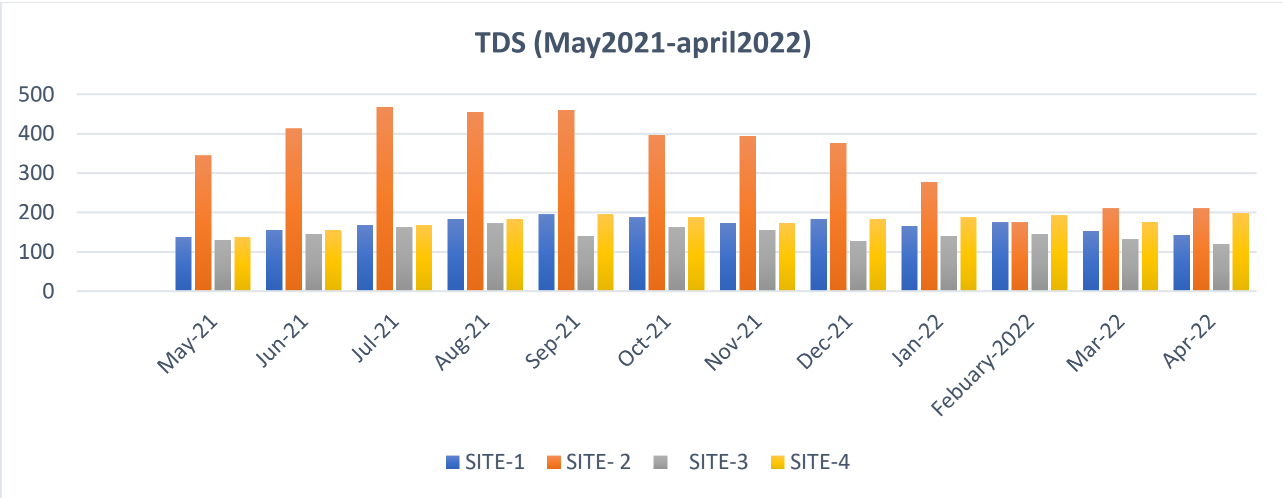


Fig.3



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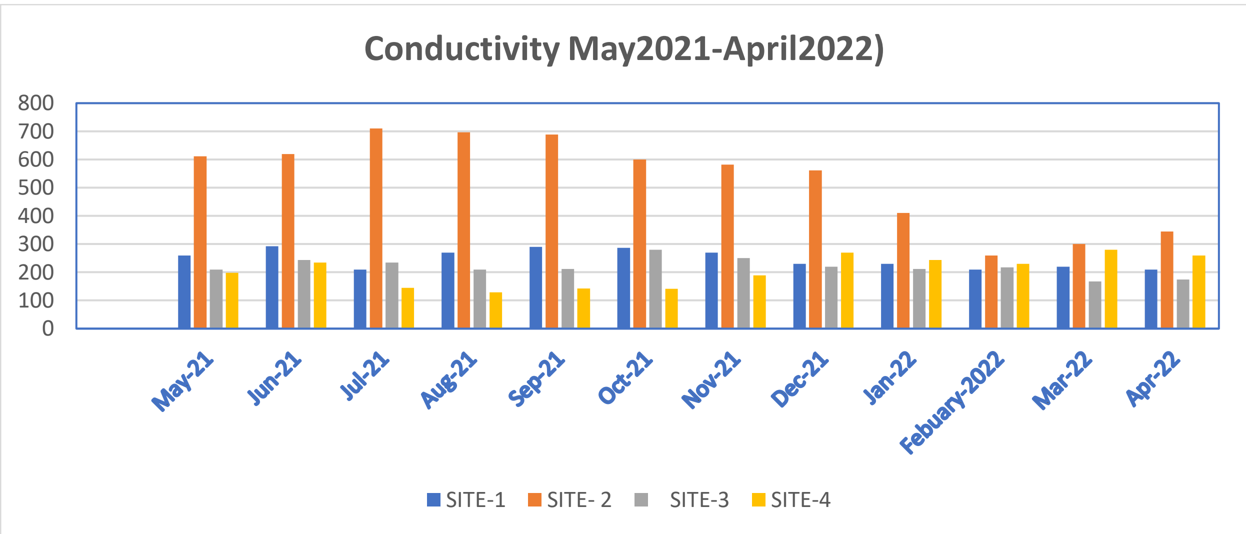

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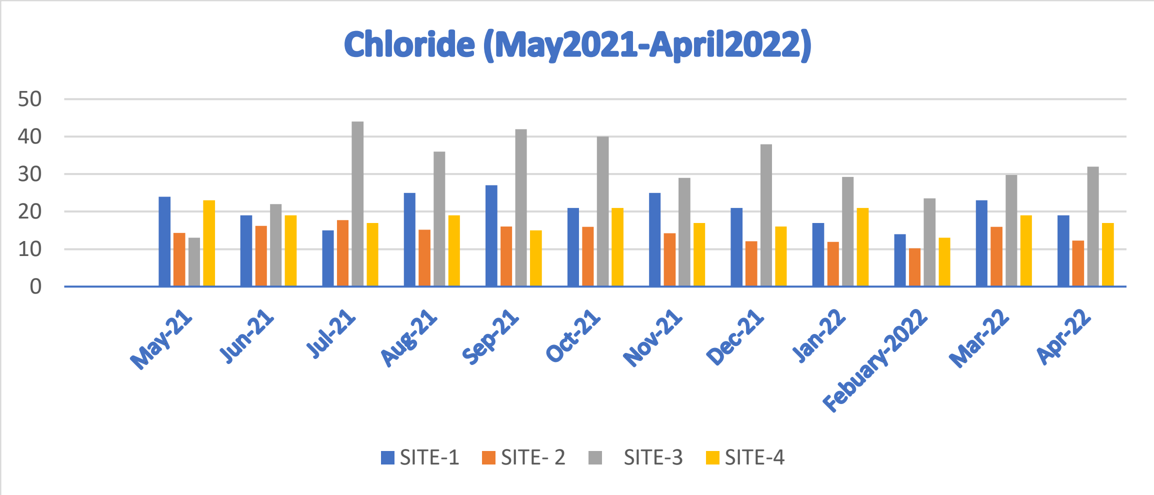

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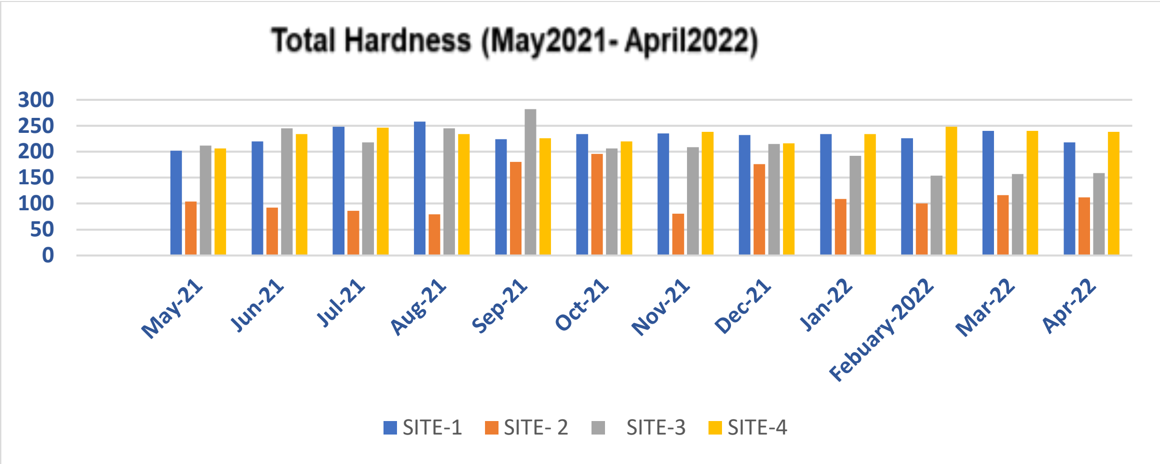

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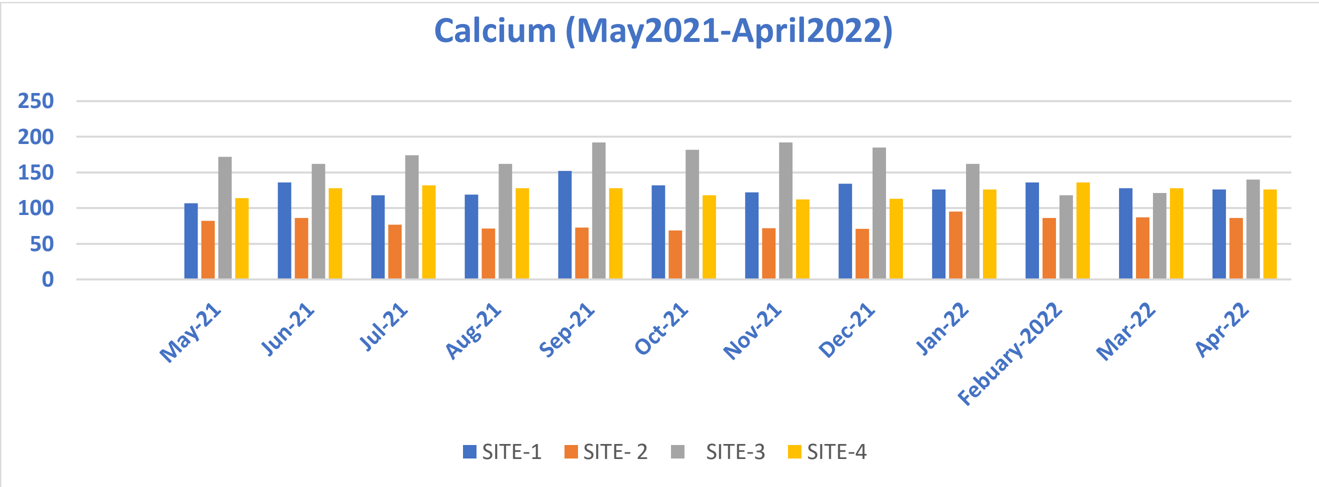

Fig.8

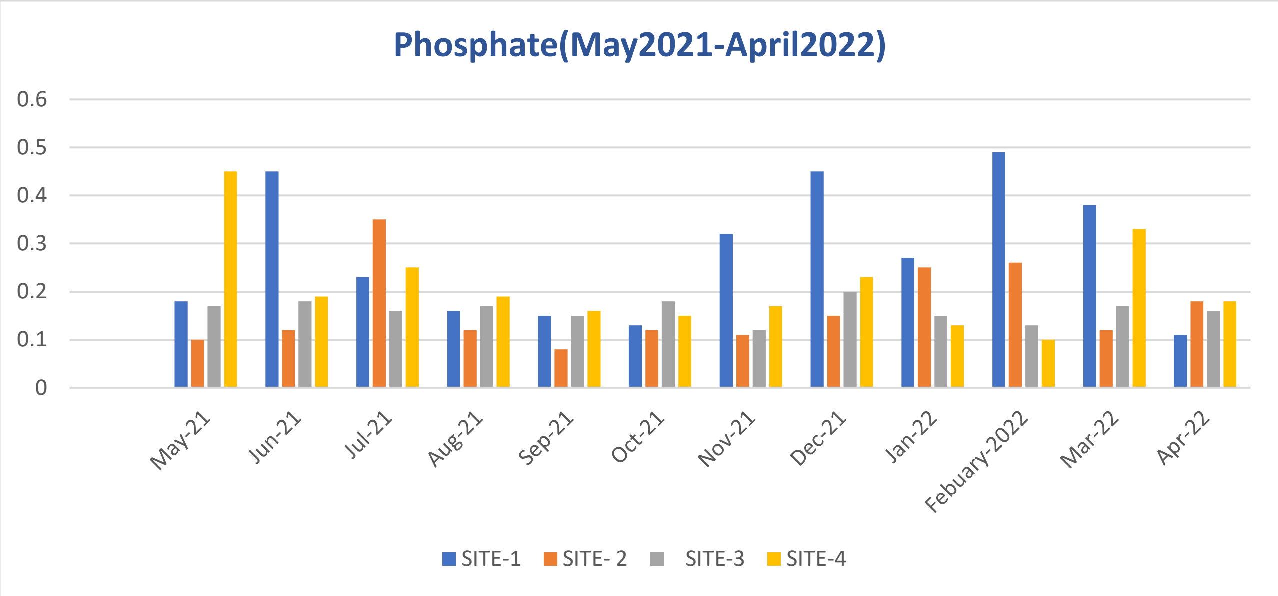

Fig.9

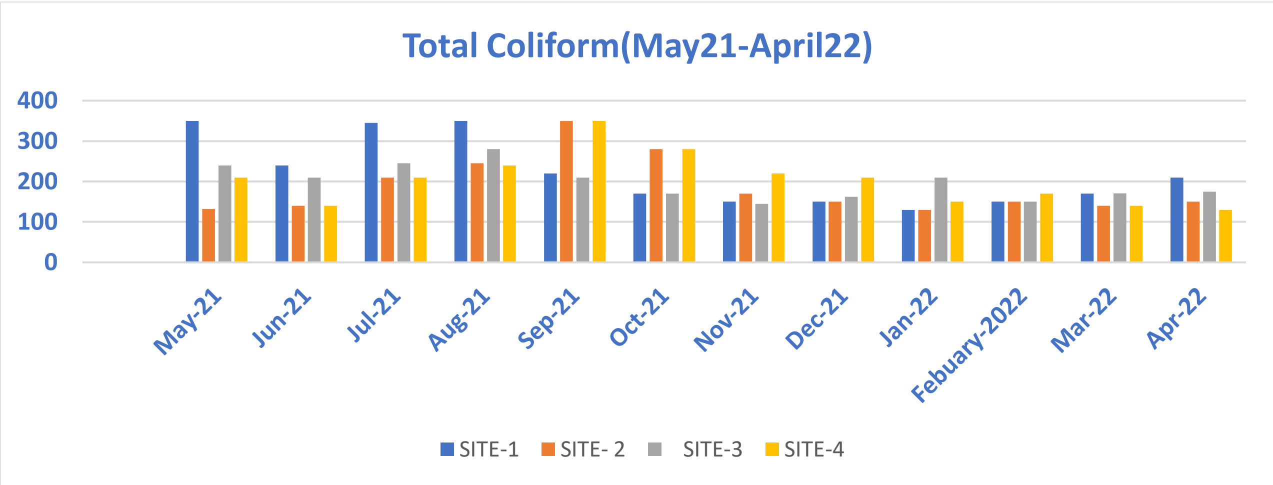

Fig.10

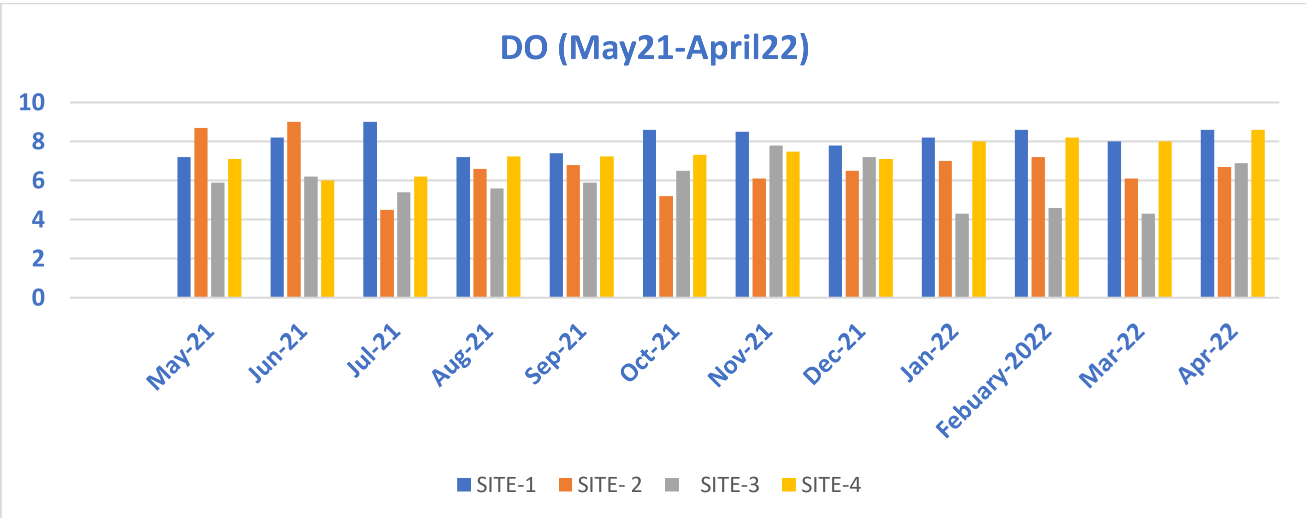

Fig.11

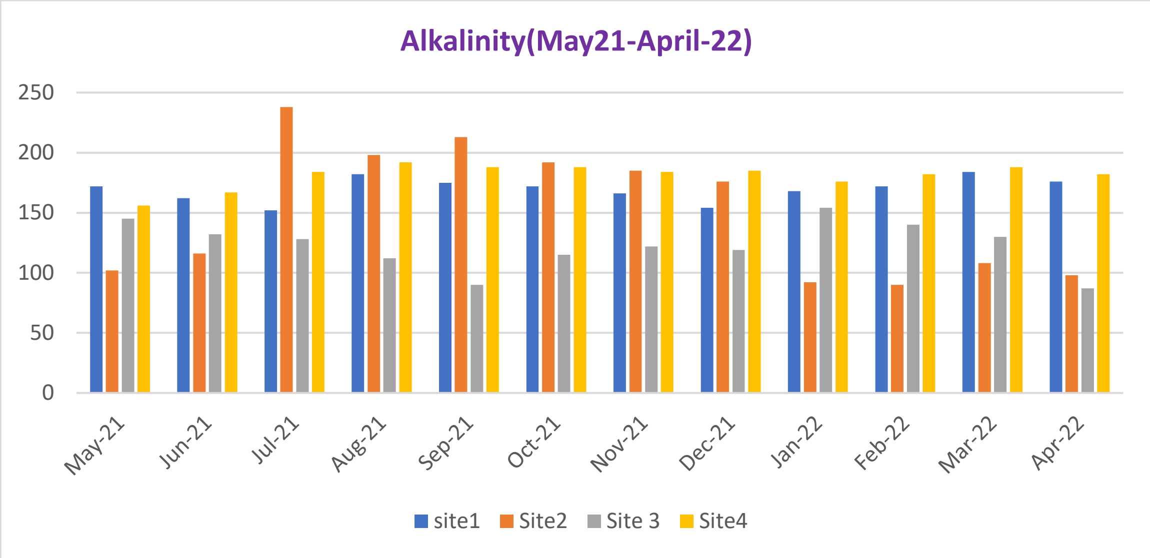

Fig.12

3.Result and Discussion

Temperature

Temperature plays a pivotal role in modulating geochemical processes within aquatic ecosystems. In the case of the Kosi River, situated within the Kumon region, thorough analysis reveals significant temperature variations. Water temperature ranges between 26°C and 32°C along the course of the river. Notably, at sampling location S4, the highest temperature recorded was 32°C, while the lowest temperature, 10°C, was observed at S1. These findings underscore the dynamic thermal profile of the Kosi River, warranting in-depth examination to comprehend its ecological ramifications.

pH

The term "pH" stands for "potential of hydrogen," serving as an indicator of the acidic or alkaline nature of water (Shah and Joshi, 2017; Kumar and Prakash, 2020). As per the guidelines set forth by the Bureau of Indian Standards (BIS, 2012), the permissible pH range for drinking water is 6.5 to 8.5, with no allowances for deviation from this limit. Analysis of water samples from the study area reveals pH values ranging from 6.1 to 8.0. The highest pH reading was recorded at sampling location S1 (7.0), while the lowest was observed at sampling location S4 (7.1) (Tripathi et al., 2016).

Alkalinity

Alkalinity serves as a crucial metric in evaluating water quality, necessitating a balanced concentration (Raju et al., 2014). The Bureau of Indian Standards (BIS, 2012) stipulates an acceptable limit of alkalinity in drinking water at 200 mg/l, with a permissible upper limit of 600 mg/l in the absence of alternative sources. In the present investigation, alkalinity levels ranged from 87 mg/l to 188 mg/l. Sampling at various locations revealed the highest alkalinity readings at both S1 and S3 during March, October, and November, while the lowest alkalinity was observed at S2 in April. These findings underscore the variability in alkalinity levels across sampling locations and seasons, emphasizing the need for comprehensive monitoring and management strategies.

Calcium

Calcium constitutes a vital component of potable water. As per the guidelines outlined by the Bureau of Indian Standards (BIS, 2012), the acceptable and permissible thresholds for calcium content in drinking water stand at 75 mg/l and 200 mg/l, respectively. Within the scope of the current investigation, calcium concentrations ranged from 70 mg/l to 192 mg/l. Analysis across various sampling locations unveiled the highest calcium levels at S1 during September, whereas the lowest levels were observed at S4 in December.

Chloride

Chloride is a fundamental constituent of aquatic ecosystems. In accordance with the guidelines established by the Bureau of Indian Standards (BIS, 2012), the permissible chloride concentrations in drinking water are defined at 250 mg/l and 1000 mg/l for acceptable and permissible thresholds, respectively, in the absence of alternative sources. The chloride concentration in water exhibits temporal variability across different months. In the current study, chloride levels ranged from 14 mg/l to 30 mg/l. Detailed sampling procedures conducted at various locations revealed the highest chloride concentration at S2 in January, while the lowest chloride content was observed at S4 in February.

Total Hardness

The primary source of water hardness stems from rocks, wherein magnesium and calcium ions are prevalent constituents, permeating water systems via runoff and percolation mechanisms. Total water hardness is a collective measure of calcium and magnesium ion concentrations (Bansal and Dwivedi, 2018; Akram and Rehman, 2018). In accordance with the Bureau of Indian Standards (BIS, 2012), the permissible thresholds for total water hardness in potable water are set at 200 mg/l for acceptability and 600 mg/l for permissibility, in the absence of alternative sources. Within the scope of this study, total hardness levels ranged from 150 mg/l to 282 mg/l. Extensive sampling endeavors conducted across various locations revealed the highest hardness readings at S2 in September, whereas the lowest hardness content was observed at S4 in May.

Nitrate

The principal anthropogenic origin of nitrate in both surface and groundwater is attributed to chemical fertilizers (Shah and Joshi, 2017). As per the standards set forth by the Bureau of Indian Standards (BIS, 2012), the acceptable threshold for nitrate concentration in drinking water is 45 mg/l, with no relaxation for permissible limits. Within the present investigation, nitrate levels ranged from 0.002 mg/l to 0.12 mg/l. Detailed sampling protocols conducted across various locations revealed the highest nitrate concentration at S4 in June, while the lowest nitrate contents were observed at S3 and S1 in March and February, respectively.

Total Coliform

The Bureau of Indian Standards (BIS, 2012) outlines a directive specifying the absence of total coliform in drinking water. Total coliform constitutes a diverse group of bacterial species originating from human and animal fecal matter, as well as other sources (Antony and Renuga, 2012). Within the scope of the current investigation, total coliform levels varied from 130 mg/l to 450 mg/l. Comprehensive sampling procedures carried out across different locations revealed the highest total coliform reading at S4 in June, while the lowest total coliform content was observed at S3 and S1 in January and February, respectively.

TDS

In natural aqueous environments, total dissolved solids (TDS) predominantly comprise carbonate, bicarbonate, chloride, sulphate, phosphate, nitrate, calcium, magnesium, sodium, potassium, iron, manganese, and other constituents (Esmaeili and Johal, 2005). Elevated levels of total dissolved solids in pond water samples signify heightened ionic concentration, which can render the water less potable and potentially induce adverse physicochemical effects in consumers. Within the present investigation, TDS levels ranged from 120 mg/l to 700 mg/l. The highest TDS concentration (697 mg/l) was identified at sampling station S4 in August, while the lowest TDS content was observed at S2 in April.

4. Conclusion

In conclusion, the comprehensive analysis of various water quality parameters across the studied water bodies provides valuable insights into their ecological health and suitability for human consumption. The observed temperature fluctuations along the Kosi River highlight its dynamic thermal profile, warranting further investigation to fully understand its ecological implications. While pH levels fall within acceptable ranges, the variations across locations and seasons emphasize the necessity of ongoing monitoring to maintain water quality compliance. The considerable variability in alkalinity levels underscores the need for comprehensive monitoring and management strategies to ensure consistent water quality. Spatial and temporal variations in calcium, chloride, and total hardness levels are influenced by geological factors and seasonal changes, necessitating continued monitoring for accurate assessment Nitrate and total coliform levels indicate the impact of anthropogenic activities on water quality, emphasizing the importance of pollution control measures. Elevated total dissolved solids (TDS) levels pose challenges to water potability, highlighting the need for measures to mitigate adverse effects on consumers. In summary, this study underscores the dynamic nature of water quality parameters and underscores the need for continued monitoring and management efforts to ensure the availability of safe and sustainable water resources for both human and ecological needs.

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