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RESEARCH ARTICLE

SEASONAL FLUCTUATIONS IN PHYSICO - CHEMICAL PARAMETERS OF RIVER SIND IN KASHMIR HIMALAYAS

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Abstract

A study was conducted to study the seasonal fluctuation in physico-chemical parameters of river Sind in Kashmir Himalayas to determine the current status of river. Water samples were collected seasonally for a period of one year from three different stations of river situated at different altitudes and were examined following the standard methods of APHA (2004). The study revealed that pH of water varied from 7.4 to 8.9 with an average value of 7.95 ± 0.47, depicting alkaline nature of water.Electrical conductivity varied from 238 µS cm^{-1} to 177 µS $cm^{-1}$with a mean value of 206.75 ± 18.41, depicting oligotrophic nature of water body.Total hardness varied from 75 mg/l to 133 mg/l with a mean value of 100.33 ± 15.59, depicting hard water nature of river. DO content varied from 8 mg/l to 13 mg/l with a mean value of 10.37 ±1.82. FCO_2content varied from 3 mg/l to 17.3 mg/l with a mean value of 9.08 ± 5.05. Total alkalinity varied from 73 mg/l to 183 mg/l with a mean value of 128.16 ± 28.74. Chloride content varied from 11 mg/l to 31 mg/l with a mean value of 22.58 ± 5.10, depicting organically polluted water. Nitrate content varied from 118µg/l to 234µg/l with a mean value of 168 µg/l ± 36.34. Total Phosphorous content varied from 43µg/l to 157µg/l with a mean value of 85.5 µg/l ± 31.1. The study further revealed that river Sind is under constant anthropogenic pressure, which is major responsible factor of current ecology of river.

Introduction:-

Water is a basic requirement for the persistence of all forms of life. In the nonexistence of water, the presence of life in any form is difficult. Water is one of the greatest sacred sign of nature to mankind which totally governs the chemical structure and metabolism of all living forms on this planet. The ubiquity of water in external as well as internal mediums of biotic forms acts as a pivot for their existence. Apart from direct contribution of water to well-being of human beings, animals, plants and economic development of any country or a region, water along with its diverse floral and faunal composition constitute an aquatic ecosystem. These aquatic ecosystems acts as hub of biological diversity by supporting and sustaining manifold forms of life ranging from primary producers like algae to tertiary consumers like fishes intermittently occupied by micro as well as macroinvertebrates (Aabida et al, 2012; Ahangar et al, 2014).

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Out of countless freshwater sources, river waters are considered as the lifelines of culture and economy of any region or country. Besides providing food, fodder and water for domestic purpose, rivers boost the economic status of country through production of electricity.But it is very disastrous that these water resources have never stayed immune to any anthropogenic stress. Most of the water bodies have lost their natural charm and have got deteriorated to a greater extent. Despite of providing many life supporting services, it is quite ill-fated that the water resources especially fresh water bodies are continuously used as disposal centers for life intimidating contaminants including domestic sewage, industrial sewage, chemical spills, agricultural wastes etc. These toxic discharges not only bring the undesirable changes in physico-chemical characteristics of water, but also disturb and disrupt the overall ecology of our valuable water resources by destroying the precious floral and faunal wealth of an aquatic ecosystem (Ahnagar et al. 2014; Gudoo et al, 2020).The river aquatic ecosystems are progressively under threat due to constant rise in level of pollution, which is sternly affecting the aquatic ecology (Khadse et al., 2008; Shraddha et al., 2011).From the Past few decades natural aquatic ecosystems have observed growing concerns about environmental evils caused by undesirable anthropogenic activities like discharge of sewage, organic waste loading, and influx of agricultural wastes.

The life supporting services provided by water bodies especially rivers makes the environmental monitoring of river waters very essential. Thus, for conservation and management of these valuable resources, enquiry on status of river waters becomes all significant. Efforts are being made constantly to keep a regular check on water quality in these natural waters. However, the examination of aquatic ecosystem is not possible without techniques and in this regard that current investigations principally focuses on the examination of physico-chemical parameters (Uherek and Pinto Gouvela, 2014).

The Union Territory of Jammu and Kashmir is considered as a paradise on earth with abundant sources of freshwater which complements to its attractive beauty. The worth of these water bodies increases manifold as these water bodies not only possess historical importance but also holds high regard due to their religious connection. But unfortunately in recent times, these water sources have come under malicious attack of undesirable anthropogenic stress which have deteriorated their water quality and have badly affected their flora and fauna (Gudoo et al, 2020; Singh, 2022). Majority of freshwater resources of Jammu & Kashmir are shrinking day by day for want of adequate measures. River Sind are among the best examples which is under constant threat of anthropogenic pressure in the form of invasion of fertilizers and pesticides from surrounding fields, sewage from nearby village, land encroachment for expansion of agricultural field etc. Keeping in view the ecologically, economically, aesthetically and religiously important services provided by the aquatic ecosystems current study was undertaken to monitor the health of River Sind through by investigation the physical and chemical parameters of river.

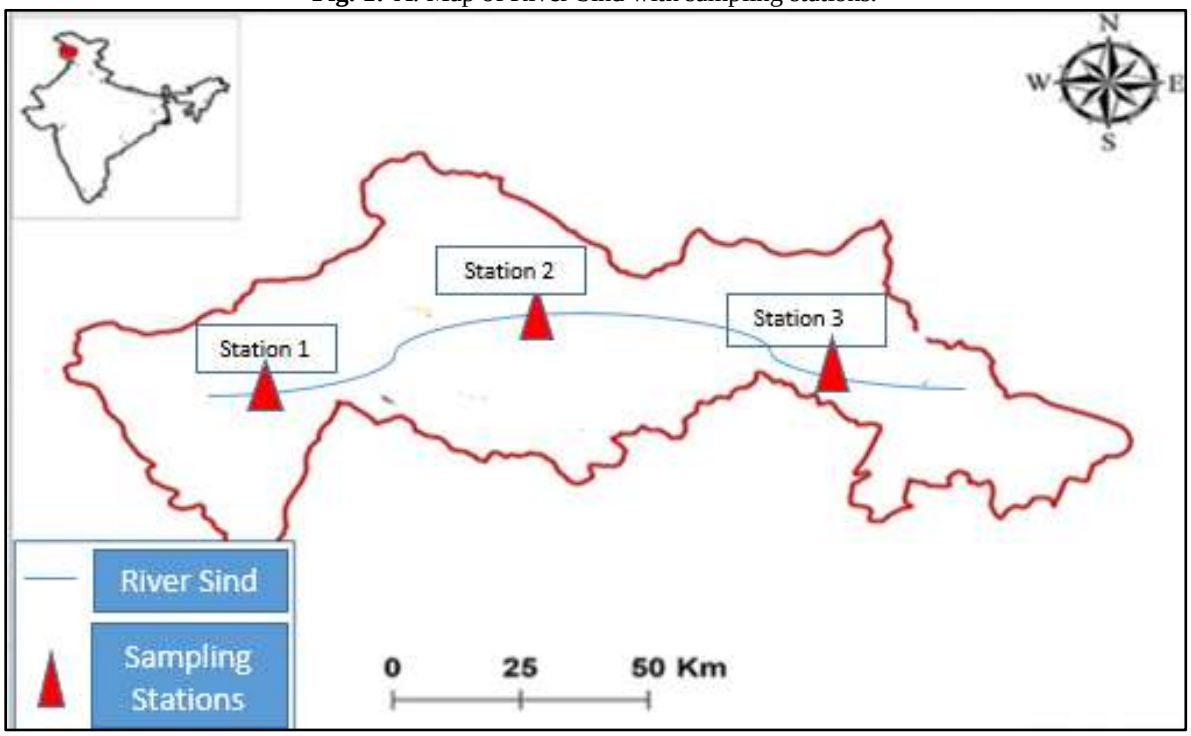
Materials and Methods:-

River Sind is a major tributary of Jhelum River in Kashmir Himalayas. River Sind is the largest of the rivers of Kashmir after River Jhelum It is situated in Kangan tehsil of District Ganderbal of Kashmir. It is located within the geographical coordinates of $34^{o}\,35^{l}$ 14.860 N and $74^{o}\,35^{l}$ 21.94 E**.** The length of River Jhelum is 108 km**.** The source of River Sind is Machoi glacier located on south of Zojila mountain range about 30 km west from Drass, Ladakh and 8 km east from Sonamarg. It flows through Panjtarni site of Amarnath cave southwards and on its way it is joined by multiple glacial waters and lead to Ganderbal town. At Kichporapreng it is joined by Wangath river which flows down from famous Gangbal lake, The major tributaries of River Sind are Amarnath stream, Shitkadinallah, Gundnallah, Wangathnallah, Surfrawnallah. . In Ganderbal town, it spreads out near Harran village and escapes by one of its tributary into Anchar lake of District Srinagar. River Sind joins River Jhelum (Vyeth) at Shadipora village of Bandipora district (Bates, 1873; Stein, 1899; Siraj, 2018).

Table 1:- Description of sampling stations in river Sind:

Sampling Stations	Latitude	Longitude	Elevation (m a.s.l)	Features of Sampling stations
Upper Stretch	34°33´ N	75.33 E	2730	Bottom contain rocks, boulders. High velocity of water
Middle Stretch	34°35´ N	74.97 E	1619	Bottom contain boulders, gravel and sand. Medium velocity of water
Lower stretch	34°28´N	74°42´E	1580	Bottom contain slit and sand. Least velocity of water

Fig. 1:-A. Map of River Sind with sampling stations.



Collection and analysis of water samples:
Sampling was performed on seasonal basis for a period of one year stretched from March 2019 to February 2020. Water samples were collected in iodine treated polyethylene plastic bottles from each sampling station. Physico-chemical analysis was performed according to standard methods of APHA, 2004. Air and water temperature, depth, dissolved oxygen (DO), pH and free carbon dioxide (FCO_2) were measured in the field during water sample collection, while electrical conductivity (EC), total alkalinity, total hardness, chlorides, nitrate, and total phosphorous, were estimated at the hydrobiology research laboratory in S.P. College, Srinagar.

Result and Discussion:-

The seasonal variation in physico-chemical parameters of water during the study period extended from March, 2019 to February, 2020 in River Sind at three sampling stations is depicted in Table-2

Temperature:
In an aquatic ecosystem temperature is of ecological significance as it regulates its various biotic and abiotic features (Katariaet al, 1995, Gudoo et al, 2020, Radikasingh, 2022). During the present study, well-marked seasonal variations were observed in air and water temperature at different sampling stations of River Sind. Air temperature varied from 23 °C at station 1 during summer seasonto 4 °C at station 3 during winter seasonwith an average value of 15.66 ± 6.74. Water temperature fluctuated from 17.5°C at station 1 during summer season to 1.9°C at station 3 during winters with an average of 10.54 ± 5.67. Water Temperature is known to be influenced directly by the temperature of air and follows same trend of alteration by exhibiting higher values in summers and a fall in winters, attributed to longer and shorter photoperiods during summers and winters respectively (Sawhney, 2008).

Depth:
The depth of water body plays a significant role in shaping the quality of water. Any variation in depth or water level in an aquatic ecosystem is mainly controlled by climatic factors including rate of evaporation, precipitation etc. The heating of water due in shallow nature of water bodies influence the interactions between various living and non-living components of an aquatic ecosystem (Sawhney, 2008).Depth varied from 0.2 m at station 3 during autumn in 2019 to 1.6 m at station 1 during summer seasonwith an average value of 0.85 ± 0.48 m in river Sind.

pH:
pH is the measure of hydrogen ion concentration in an aquatic ecosystem (Wetzel, 2001). It is an important physicochemical parameter affecting overall changes in hydrobiological characters (Gudoo et al, 2020). pH changes are influenced by carbonates, bicarbonates and carbon complexes in water (Singh, 2022).pH values varied from 7.4 at station 3 during winter season to 8.9 at station 1 during spring season with an average value of 7.95 ± 0.47 in river Sind. Increase in pH values during spring season could be due to increased rate of photosynthetic activity by aquatic flora and phytoplanktons. The present observations draw support from findings of by Singh (2004) and Chowdhary (2011). Fall in pH during winters due to dilution effect by high precipitation and flow of glacial water in river as also opined by Gudoo (2019) and Singh (2022).

Electrical conductivity (EC):
Electrical Conductivity is the capacity of a substance or solution to conduct electrical current.EC values varied from 238 μS cm^{-1} at sampling station 1 during summer season to 177 μS cm^{-1} at sampling station 3 during winter season with a mean value of 206.75 ± 18.41 in river Sind.

The fall electrical conductivity during winters is due to decreased decomposition rate of organic wastes at low temperature while as summer maxima is because of emission of nutrients as a result of decomposition of organic matter in lake waters and increasing organic and inorganic loading in lakes from immediate catchments especially at lower and middle stretches of River Sind. According to the reports of Olsen (1950), the water bodies having electrical conductivity value above 500 μS/cm is categorized as eutrophic water body and the water body having electrical conductivity value less than 300 μS/cm are characterized as oligotrophic water bodies. As per this classification river Sind is an oligotrophic water body. The desirable range of Electrical conductivity according to WHO (2011) is 750 (μS/cm).

Total Hardness:
Hardness reflects concentration of metallic cations like Calcium, magnesium and carbonates, bicarbonates, sulphates, chlorides, nitrates, soap, detergent and organic matter in water.Total hardness varied from 75 mg/l at station 3 during spring season to 133 mg/l at station 1 during winter season with a mean value of 100.33 ± 15.59 in River Sind.

Winters maxima of hardness is due to less macrophytic and algal growth at low temperature and increased solubility of ions at low temperature. The lower values obtained for total hardness during spring and summers may be attributed to utilization of carbonates and bicarbonates by phytoplanktons as a source of carbon and reduced solubility of calcium ions at higher temperature.The observations coincide with the findings ofBhat et al. (2013); Ahangar (2014); Gudoo et al. (2018); Gudoo (2020). The desirable limit for hardness is 300 mg/L (WHO 2011). Lehr et al.,(1980) provided the hardness scale of water, according to which, the water bodies with hardness values between 0 to 17 mg L^{-1} are considered as soft water bodies, the water bodies having hardness values between 17 to 60 mg L^{-1} are considered as slightly hard water bodies, the water bodies with hardness values between 60 to 120mg L^{-1} are considered as moderately hard water bodies, the water bodies with hardness values between 120 to 180 mg L^{-1} are considered as hard water bodies and the water bodies with hardness values greater than 180 mg L^{-1} are considered as very hard water bodies. As per the hardness scale. River Sind reveal hard water type nature.

Dissolved Oxygen (DO):
Dissolved oxygen helps in evaluating any change in quality of water and regulate the metabolic processes of all living forms in water. DO concentration of an aquatic ecosystem varies with temperature, turbulence, photosynthetic activity etc. (Gudoo et al, 2018). During current study, DO content varied from 8 mg/l at station 1 during summer season to 13 mg/l at station 3 during spring season with a mean value of 10.37 ±1.82 in River Sind.

The fall in DO during summers may be attributed to high temperature (Ibrahim et al., 2006), high decomposition of organic matter (Gudoo, 2019) .The rise in DO during winters and spring may be attributed to low temperature and aeration due to high precipitation (Ali et al., 2014; Sharma, 2002) and less decomposition rate of organic matter (Ahanger (2014). Further high velocity of water at station 3 also enhance the DO content of water.

Free carbon dioxide (FCO_2):
In a water bodies carbon dioxide reacts with water and lead to formation of carbonic acid which on decomposition form carbonates and bicarbonates and thus cause alteration in pH of water.

FCO_2content varied from 3 mg/l at station 3 during spring season to 17.3 mg/l at station 1 during winter season with a mean value of 9.08 ± 5.05 in River Sind.

The higher free carbon dioxide values recorded during winters may be attributed toless macrophytic growth and reduced solubility of carbon dioxide in water at low temperature, while as lower values recorded during spring may be attributed to enhanced photosynthesis and abundant macrophytic growth. The results coincide with the findings of Zuber (2007); Akharet al.(2015) and Gudoo et al. (2018).

Total Alkalinity:
Alkalinity refers to the tendency of water to neutralize the acids present in it and is basically because of concentration of carbonates, bicarbonates in water generated as a result of dissolution of carbon dioxide in water. The submission of carbonate and bicarbonate alkalinity constitutes total alkalinity (Gudoo, 2018, Gudoo, 2019, Gudoo, 2020).

Total alkalinity varied from 73 mg/l at station 3 during spring season to 183 mg/l at station 1 during summer season with a mean value of 128.16 ± 28.74 in River Sind.

High total alkalinity during summers is attributed to higher temperature associated with higher decomposition of organic wastes. The lower values obtained for alkalinity during spring may be attributed to absorption of nutrients at higher rate by macrophytes and phytoplanktons. The results are in agreement with the findings of Naik, (2005); Akthar et al. (2015); Gudoo (2019). The desirable range of Alkalinity is 300 mg/l.

Chloride content:
Chloride content in water is an excellent indicator of organic matter load. The high chloride concentration reflect the organically polluted nature of water body. (Venkatasubramani and Meenambal., 2007, Gudoo et al, 2018).

Chloride content varied from 11 mg/l at station 3 during winter season to 31 mg/l at station 1 during summer season with a mean value of 22.58 ± 5.10 in River Sind.

Higher values of chloride in summer season is a result of accelerated decomposition rate autochthonic material (Sharma, 2002). The winter fall in chloride content is attributed to decreased water temperature associated with low decomposition of organic wastes and dilution of water by winter rains (Gudoo, 2019).

Nitrate-nitrogen:
Nitrates are common form of inorganic nitrogen in aquatic ecosystem produced by the action of nitrifying bacteria on nitrogen rich agricultural and domestic wastes (Gudoo, 2019).

Nitrate content varied from 118µg/l at station 3 during winter season to 234µg/l at station 1 during summer season with a mean value of 168 µg/l ± 36.34 in River Sind.

Summer elevation of nitrate content may be attributed to increased rate of decomposition of organic watses, rotting of macrophytes and agricultural waste input. The reduction in the concentration of nitrates during winter season is attributed low temperature associated with reduced rate of decomposition at low temperature. The results draw support from findings of Naik (2005); Zuber (2007), Ahanger at al. (2014), Gudoo et al. (2018).

Total Phosphorous:
Phosphorus is primary cause eutrophication in aquatic ecosystem. Main sources of Phosphorous are domestic sewage and agricultural run-off containing fertilizers (Gudoo et al. 2017, 2018, 2020, 2021).

Total Phosphorous content varied from 43µg/l at station 3 during winter season to 157µg/l at station 1 during summer season with a mean value of 85.5 µg/l ± 31.1 in River Sind.

Summer maxima of phosphorous content is due to increased agriculture runoff, elevated decomposition rate at high temperature (Shindeet al. 2010. The decreased concentration of total phosphorus during winters and spring may be attributed to low decomposition rate at low temperature and increased utilization of phosphorous by macrophytes

which grow vigorously during spring and summers that lead to decrease in phosphorous towards winters (Gudoo , 2019).

Table 2:- Seasonal variations in various physico-chemical parameters of water in River Sind during the study period (2019 - 2021).

Parameters	Station-1 (Lower stretch)		Station-2 (Middle stretch)		Station-3 (Upper stretch)		Mean ± SD
	Min.	Max.	Min.	Max.	Min.	Max	
Air Temperature (^{0}C)	6	23	5.5	22..5	4	22	15.66 ± 6.74
Water Temperature (^{0}C)	2.1	17.5	2.0	16.4	1.9	15.2	10.54 ± 5.67
Depth (m)	1.3	1..6	0.3	0.9	0.2	0.8	0.85 ± 0.48
pH	8.1	8.9	7.7	7.9	7.4	7.6	7.95 ± 0.47
Conductivity (µS cm^{-1})	212	238	198	222	177	201	206.75 ± 18.41
Total Hardness (mg/l)	93	133	88	115	75	106	100.33 ± 15.59
Dissolved Oxygen (mg/l)	8	12.5	8.1	12	8.2	13	10.37 ±1.82
Carbon dioxide (mg/l)	4.5	17.3	4	17	3	15	9.08 ± 5.05
Alkalinity (mg/l)	107	183	106	162	73	147	128.16 ± 28.74
Chloride (mg/l)	21	31	22	28	11	22	22.58 ± 5.10
Nitrate-Nitrogen (µg/l)	167	234	139	198	118	148	168 ± 36.34
Total phosphorous (µg/l)	77	157	51	97	43	77	85.5 ± 31.1

Conclusion:-

The present study concludes that as result of multiple factor including both natural and anthropogenic factors, the physico-chemical parameters of river Sind reveal as well marked seasonal fluctuations. The river Sind reflects oligotrophic status. The river water is alkaline, hard and more or less organically polluted. The study further reveals that anthropogenic activities including dumping of wastes, input of domestic sewage, agricultural run-off etc. into the river from catchment areas are major factors contributing current ecological status of river.

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