Journal of the Kalash Science
Volume-12, Number-1, 2024 : 9-25

Website: www.kalashj.com
E-mail: saajjjan@rediffmail.com
ISSN: 2321-7634

Assessment of self purification response of Sai river, Uttar Pradesh in the relation of the seasonal variation

Adi Nath[1]*, Abhijeet Sharma[2], Kavita Singh[1], Shailendra Kumar Singh[3], Shanthy Sundaram[2]*
[1]Department of Botany, Nehru Gram Bharati deemed to University, Prayagraj-221505India
[2]Centres of Biotechnology, University of Allahabad, Prayagraj-211002, India
[3] S S Khanna Girls Degree College Allahabad, Prayagraj-211002, India
Corresponding author Email:shanthy.cbt@gmail.com, [1] Email:adinathupadhyay@gmail.com

Accepted : 17 March 2024

Abstract

This study examines the intricate interactions between environmental elements and human activity, with a particular emphasis on the COVID-19 pandemic's impact. The multi-year study, which looks at the physicochemical characteristics of water, sheds light on how human activity affects the environment of rivers. Results show significant variations in pH, which are related to the elimination of medications prescribed for COVID-19 treatment. Particular conductance shows significant increases during the rainy season and decreases during the summer, when dissolved oxygen levels are expected to be lower. The peak months for total dissolved solids are July and August, when a variety of human activities take place. Concentrations of dissolved organic materials rise, signifying medicine and sewage. Bio-available oxygen pollution risks are highlighted when demand exceeds permissible limits. Propose limiting the amount of sewage released in the summer. In order to maintain and improve the ecological health of the river, the results highlight the necessity of sustainable water management techniques as well as pollution control measures.

Keywords: Anthropogenic activities, Covid-19, Biological Oxygen Demand (BOD), Sai River

Introduction

Water, as nature's greatest gift to mankind, is the fundamental necessity of life. The continuous movement of water on Earth through the processes of evaporation, transpiration, condensation, precipitation, and runoff forms the water cycle. Water plays a pivotal role in the global economy, with approximately 70% of freshwater usage by humans being allocated to agriculture, fulfilling the essential need for food and nutrition. This study represents the initial phase of a comprehensive program. Initially conceived as a straightforward exercise to forecast water demand and supply for major countries worldwide from 1900 to 2025, the study has evolved. Furthermore, many parts of the world are susceptible to devastating floods, which result in the highest toll of death and destruction among various types of calamities. Both water scarcity and excessive water can hinder the progress of developing countries towards sustainable development, as advocated by the UN Conference on Environment and Development (UNCED) and its report. The analysis of this data remains rudimentary in various areas.

In India, the agricultural sector is the largest consumer of water, accounting for 90% of total freshwater usage. Municipalities utilize 7% of the water supply, while industry accounts for 3% (according to the Food and Agricultural Organization). Irrigation alone contributes to 55-70% of water consumption in the country. It is crucial to conduct a comprehensive assessment of water resources to enable integrated river basin planning and management. Without this, the pursuit of sustainable development will remain elusive. Normally water contains two types of impurities-dissolved and suspended. Dissolved impurities which consist of gases (H_2O, CO_2, NH_3, etc.) and minerals (Ca, Mg, Na, Salts). Suspended matter includes clay, silt and sand and even microbes. Polluted waters are turbid, unpleasant, foul-smelling, unfit for drinking, bathing and washing or other purposes (Chatanga *et al*. 2019, Tiwari *et al.* 2016, Batabyal 2023, Akoto *et al.* 2021, Chen *et al.* 2021, Bowes *et al.* 2020,). In India about 370-million-hectare meters of water is received as an annual rainfall over the entire country. About 30% of it is evaporated immediately and about

22% seeps into the soil and rest of the water flows into the large drainage. This waste effluent was run-off through drainage. By this system it may change or disturb the river water quality due to percolation of water contents high attainments of some parameters, like hardness, BOD, DO, chlorides, nitrates and some heavy metal produced from human and industrial activities (Misra 2011, Dwivedi *et al.* 2016a, Maria *et al*. 2019, Jaiswal & Pandey 2019, Kishor *et al.* 2021, Kannaujiya & Tiwari 2023)common ions and nitrate of sodium, potassium magnesium and calcium etc. keep accumulating in the stream once added (Munawar *et al.* 2022, Muduli *et al*. 2021, Naik *et al.* 1996). The standard value prescribed by DIS, ICMR and WHO for their suitability as drinking water quality. The water quality parameters are used to compare with corresponding standard values to determine waste quality index (chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/https://cpcb.nic.in/wqm/BIS_Drinking_Water_Specification.pdf 468, https://cpcb.nic.in/water-quality-criteria/, https://nmcg.nic.in/NamamiGanga.aspx,https://www.who.int/publications/i/item/9789241565486).

Water contains various type of impurities such as dissolves gases (N_2, NH_3 and H_2S) dissolve minerals (salt of Na m Mg and Ca) suspended matter (silt and clay) and even microbes (Gupta *et al.* 2023, Hirapara *et al.* 2022, Rad *et al.* 2022 Dong *et al.* 2020, Aggrawal *et al.* 2020, Reddy *et al.* 2019 Carvalho & Santos 2016, Mayank & Dwivedi 2015).It is always better to protect ground water first rather than relying on technology to clean up water from a contaminated source. Ice caps and glaciers account for 76.6% of fresh water source on earth followed by ground water 22.7% and surface water, a mere 0.5%. The disposal of solid and liquid wastes are containing heavy metal like lead, Nickel, Chromium, Molybdenum and Mercury in land or water bodies. Lead to heavy metal contamination of the soil water plant animal's ecosystems. Good quality water is inadequate even for the normal living and is getting polluted due to industrial discharges, including those of papers, textiles, rayon, fertilizers, pesticide, detergents, synthetic drugs, antibiotics, oil refineries and photo films (Tariq & Mushtaq 2023, Su *et al.* 2023, Sharma & Kaushik 2023, Rice *et al.* 2022, Subba Rao *et al.* 2022, Rao 2021).

Major Indian Rivers such as Ganga, Yamuna, Tapti, Narmada, Sone, Chambal, Daha, Damodar, Krishna, Kaveri, Brahmaputra, Mahi and other rivers or severally polluted (Kumar *et al.* 2021, Kumar *et al.* 2020, Tripathi *et al.* 2017, Dutta *et al.* 2020, Dwivedi *et al.* 2020, Kumar *et al.* 2020, Kulkarni 1973, Dwivedi *et al*. 2016b, 2018). To observe the extent of the pollution in the major rivers, synthetic observation at different distances of the river is being made (Raman *et al.* 2023, Mohanty *et al.* 2023, Wang *et al.* 2022, Zhang *et al.* 2022, Quadri & Padala 2021, Purohit *et al*. 2020, Zhang *et al.* 2019).

Self-purification is the process in which balance restoration of aquatic environment take place through the simultaneous or sequential participation. Water reservoirs depending upon its physico-chemical and biotic characters purify the bulk as a function of pollutants presents there in (Muduli *et al.* 2021). The process of self-purification involves the physical chemical and biological interactions occurring between the surface of reservoirs and the pollutants in water. The surface property of reservoirs namely, the surface area, unevenness, prevalence's and the composition of the surface material decide the self-purification efficiency of the reservoirs. Some biotic materials such as plants and animals also cause purification of water by depriving it from pollutants. Understanding the impact of seasonal variation and human activities is crucial for monitoring the health of rivers. These waterways play a vital role in supporting surrounding ecosystems, so any decline in water quality can have far-reaching consequences. To address this pressing issue, our study delves into the behavioral changes of the Sai River, a critical local water ecosystem. Focusing on a significant stretch of the river, we aim to evaluate the effects of human and environmental factors on its overall health. Our research sheds light on the ground reality of small rivers, which are particularly vulnerable to the influence of their surrounding environment.

Materials and Method

General survey of sites and scenario

Since parts rivers, lakes and underground water had been a major source of water supply to sustain life on the earth. These different zones are used as public for different purposes drinking as cattle,

washing, bathing, irrigation and other purpose. Due to different factors this source of water.

Selection of different site for physico-chemical and biological analysis

Out of the site locate in each zone to expect were selected for analysis (S1-Ramdayalganj bridge, S2- Gutwan bridge, S3- Bishunpur, S4- Bakhopur, dhirdas, S5- Gahora, S6- Hansrauli, S7- Old Bargudar, S8- Devapur, S9- Rajepur Fig. 1). The pollution parameters of these sites were measured in first week of each month at monthly intervals from August 2022 to July 2023. Each sample for different sampling sites were brought to the laboratory in inbox for the analysis of various physico chemical parameter viz. temperature, PH, hardness, alkalinity bacterial coliform, DO, BOD, Iron, Calcium, Copper, Chromium, Chloride, Nitrate & Sulphate. These samples were collected in thoroughly cleaned polythene container of two-liter capacity provided with double cap and filled up to the top without leaving space. For bacteriological analysis sample were taken in 200ml sterilized bottle containing 1.8% sodium thiosulphate solution leaving some space for bacteria to survive whereas for heavy metal analysis, these were collected in 100 ml polythene containers rinsed several times with (1+1) nitric acid and finally with distilled water and to these 5ml conc. Nitric acid (AR grades) per liter of sample was added, temperature of water was recorded on the sampling site within the bulk. The average value of each zone on either side of the canal was determined and the value has been recorded in the table.

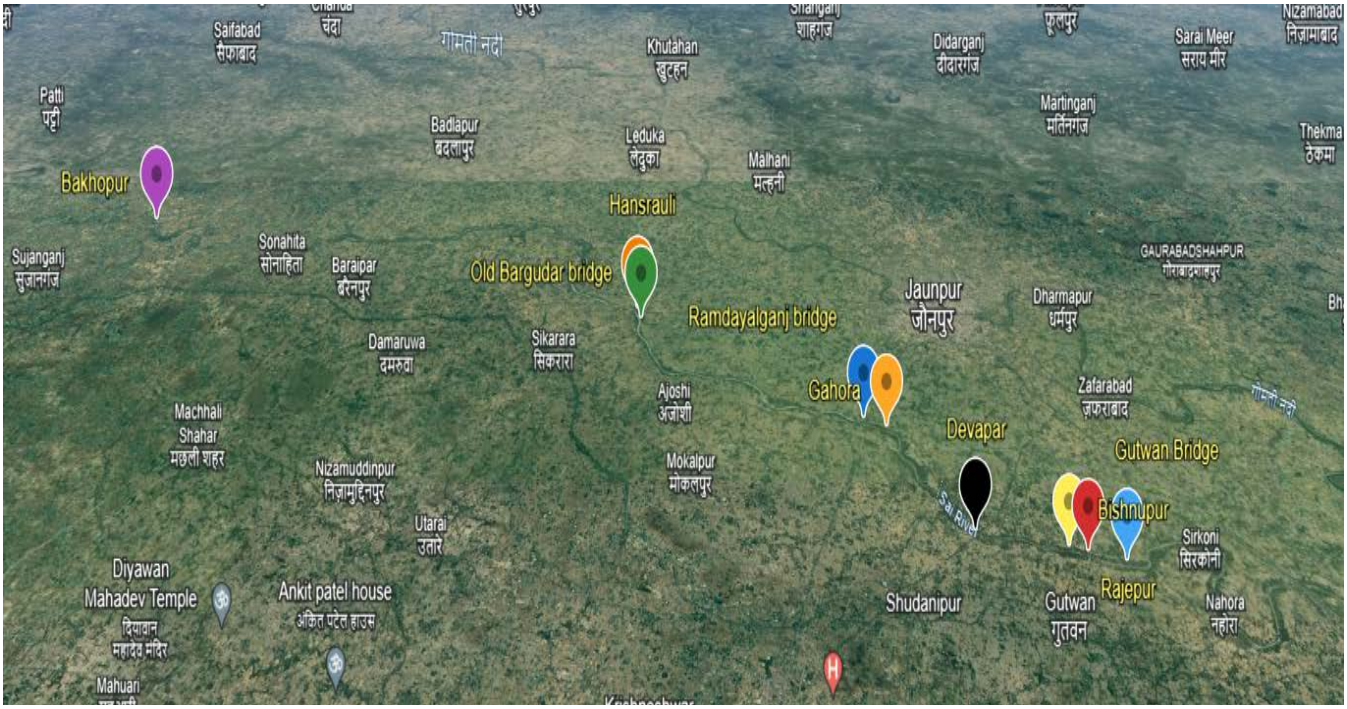


Fig. 1. Sampling Sites Google earth location

Sampling and Analytical methods

For removal of different types of pollutants from water and used water different types of technique have been used. The methods for different removal of organic and inorganic pollutants are as follows:

Biological Methods: Biological methods are based on the accumulation of trace elements, organic pollutants by marine organisms (Jadhav & Purohit 2008)

Chemical Methods: The important chemical method for the treatment of water and waste water was precipitation reduction, chemical coagulation

technique and ion exchange method. The soluble metallic ionic pollutants were removed by reduction and precipitation methods (Jadhav & Purohit 2008).

Physical Method: By flotation method, bubbling methods, sedimentation methods suspended particles like, sand, clay, gravels were suspended particle could be removed from the solution (Jadhav & Purohit 2008).

Integrated Methods: The integrated methods may be biochemical biophysical and biophysico-chemical. The adsorption techniques were now considered as an advance and popular techniques (Jadhav & Purohit 2008).

Physico chemical and biological analysis of river water

Temperature: For the physico-chemical analysis of water various methods have been adopted (Jadhav & Purohit 2008).

Surface temperature: Surface temperature was measured by using thermometer (Surface Testing Temperature Meter PCE-779N).

Depth temperature: Depth temperatures are measured by a number of devices such as thermistor, thermophone, bathythermograph, reversing thermometer etc. Thermistor (SOCAY power NTC Thermistor MF-72-SCN10D) based on the principle of developing different intensity of charges on a resister in different temperature. In bathythermograph a copper tubing is filled with xylene which expands or contracts and activates a special element carrying a stylus. The styles record on a coated glass, slides. The movement of the element's conductivity. The correction factors can be obtained from the following equation:

$T = T_1 + T,$

where,

$$T = \frac{(T_1 - t)(T_1 + V_0)}{K - 100} + I$$

T = Corrected temperature of reversing thermometer.

T_1 = Uncorrected reading of reversing thermometer.

t = Temperature from auxiliary thermometer at which reading is taken.

V_0 = Volume of small bulb and of capillary up to 0°C graduation.

K = Constant depending upon the relative expansion of mercury and the type of glass used in thermometer (use value of K=6100).

I = The individual of calibration (e.g. from the certificate) correction for reversing thermometer. Instead of including in tedious calculation several time, T can be obtained from a graph drawn for values of T_1 and t in relation to T.

Odor: Prepare the odor free water by filtering tap water or distilled water through a bed of activated charcoal. The tap water must be free of residual chlorine, unusual high concentration of salts and unusually high or low PH. The determine of approximate range of threshold odor number (T.O.N) diluting 200 ml, 50 ml and 2.8 ml of sample in a 500 ml glass stopper Erlenmeyer flasks to 200 ml with odor free water. Put these flasks in water both at desired temperature. One blank with only odor free water is also kept. Find out the maximum dilution at which odor can be detected. Take further dilution of the sample on the basis of preliminary range of T.O.N and the find out the dilution at which odor is just detected at particular temperature. Blanks are also inserted in between the sample dilutions. Let the observed smell the flasks in sequence from least concentration of the sample observers should not know about dilution about dilution in the flasks, and blanks. Record the observation on the basis of whether odour is detected in each flasks as follows:

Ml sample diluted to 200ml	1.4	2	0	2.8	4	5	7	8.3	0	12
Response	–	–	–	–	–	+	+	+	–	+

Taste: Prepare the same dilution as in the case of determination of odor. To bring them desired temperature in water bath. Present the dilution to the observed in 50 ml beaker field up to the level of 30 ml, also entered a blank with each dilution. To observe test the samples by taking suitable volume of it into the mouth for same time and removing it without swelling. To observe compare the taste with

the blank and record whether the sample give a taste or after test.

Sample should be given to observe in the sequence from lower concentration to higher concentrations.

Calculation

Threshold taste number (T.T.N) = (A+B) / A

Where,

A = ml sample in the diluted total volume of sample.

B = ml dilution water in the diluted total volume of sample.

Turbidity: Nephelometric method- For handling the Nephelometer, followed the instructions supplied by the manufacturer. Seted the instrument at 100 with the 40 NTU standard suspensions. In this case, every division on the scale will be equal to 0.4 NTU turbidity. Shaked thoroughly the sample, and keep it for some time to eliminate the air bubbles. Put the sample in the Nephelometer sample tube and find out the value on the scale. The sample is suspected to have more turbidity (more than 40 NTU) diluted it so that turbidity values come below 40 NTU, and take the reading.

Calculation

Turbidity, NTU = Nephelometer reading × 0.4 × dilution factor.

Light penetration: Secchi Disc Method- Lowered the Secchi disc in the water with the help of the string tied to it, until it just disappears. Noted the depth by marking on the string. Then uplift the Secchi disc and noted the depth at which it reappears again. For better results, measurements should be made during the middle of the sunny days.

Calculation

$$\text{Secchi disc light penetration} = \frac{A+B}{2}$$

Where,

A = depth at which Secchi disc disappears

B = depth at which Secchi disc reappears.

pH: Follow the instructions given by the manufactures to use the pH meter. Essential aspect to use the entire pH meter is to calibrate it will suitable buffers. Ready buffers of PH values are also available in the market. Set pH meter with a buffer whose value is near to expected pH of sample. Buffers of different pH values can also be made in the laboratory in the following manner.

Potassium hydrogen sulphathalate buffer: Dissolved 10.2gm of potassium hydrogen phthalate in water prepare 10000ml of buffer.

Phosphate buffer: Dissolved 3.40gm of KH_2PO_4 and 4.45gm of $Na_2HPO_4.2H_2O$ in water to prepare 1000ml of buffer.

Borax buffer: Dissolved 3.81gm of $Na_2B_4O_7.10H_2O$ in water to prepare 100ml of buffer. The values of the above buffers at various temperatures are as follows.

Temperature (0°C)	Phthalate	Phosphate	Borate
0	4.01	6.98	9.46
5	4.00	6.95	9.39
10	4.00	6.92	9.33
15	4.00	6.90	9.27
20	4.00	6.88	6.22
25	4.01	6.86	9.18
30	4.01	6.85	9.14

Hardness: EDTA METHOD- Hardness is generally caused by the calcium and magnesium ions present in water. Polyvalent ions of some other metals like strontium, iron, aluminum, zinc, and manganese etc. are also capable of precipitating the soap and thus contributing to the hardness. However the concentration of these ions was very low in natural water. Therefore the handiness is generally measured as concentration of only calcium and magnesium as calcium carbonate, which were for higher in quantities over other hardness producing ions.

Calcium and magnesium form a complex wine red color with Eriochrom Black T at pH of 10.0 + 0.1. The EDTA has got stronger affinity towards Ca^{++} and Mg^{++} and therefore by addition of EDTA the former complex is broken down and new complex of blue color is formed.

Buffers Solution: 16.9 g of ammonium chloride and 1.25 g of magnesium salt of EDTA is dissolve in 143ml of concentrated ammonium hydroxide and diluted to 250 ml with distilled water.

Eriochrom black-T indicators: 0.5 g of Eriochrom black-T indicator is dissolved in 100 g of triethanolamine.

Standard EDTA Titrant: 0.01 ml or NgAR grade EDTA is dissolved in distilled water and diluted to 1000ml and is standardized against standard calcium solution 1ml $CaCO_3$.

Standard Calcium Solution: 1.0 g of AR grade $CaCO_3$ is weighted in to a 250 ml conical flask, to which 1+1 HCl is added till all $CaCO_3$ is

Dissolve completely: 200 ml of distilled water is added and boiled expel carbon dioxide and diluted to 1000 ml. 1 ml = 1 mg $CaCO_3$. Exactly 50 ml of well mixed sample is pipetted a conical flask to which 1ml of ammonium buffer and 2-3 drops of Eriochrom black-T indicator is added. The mixture is titrated against standard 0.01 ml EDTA until the wine red color of the solution turn pale blue at the point.

Calculation

Total hardness = (T)(1000)/V

Where,

T = volume of titrant

V = volume of sample

Calcium Hardness: The process of calcium (fifth most abundant) in water result from passage through or over deposit of limestone, dolomite, gypsum and such other calcium breaking rocks. Calcium contributes to the total hardness of water and is an important macro nutrient in aquatic environment and is especially needed in large quantities by molecules and vertebrates. It is measured by EDTA titrimetric method. Small concentration of calcium carbonate prevent the corrosion of metal pipes by lying down a protecting coating but increased amount of calcium precipitates on heating to form harmful scales in boilers, pipes and utensils.

A known volume (50 ml) of the sample is pipetted in to a clean conical flask to which 1ml of sodium hydroxide and 1ml of isopropyl alcohol is added. A pinch of murexes indicator is added to this mixture and titrated against EDTA until the pink color turn purple.

Calculation:

$$Calcium\ Ca(mg/L) = \frac{T}{Sample\ taken\ ml}$$

$$Calcium\ hardness\ (mg/L)\ CaCO_3 = \frac{T \times 1000 \times 1.05}{Sample\ taken\ ml}$$

Where T = Volume of titrant, ml

Magnesium Hardness: Magnesium is a relatively abundant element in the earth crust, ranking eight in abounds among the elements. It is found in all natural water and is the source lie rocks, generally present in lower concentration than calcium. It also an important element contributing to hardness and necessary constituent of chlorophyll. Its concentration greater than 125mg/l influence cathartic and Diuretic action.

Calculation:

Magnesium (as mg/l) = (T – C) × 0.243

Where,

T = Total hardness mg/l (as CaCO3)

C = Calcium hardness mg/l (as $CaCO_3$)

Biological Oxygen Demand: Biological oxygen demand is amount of oxygen require by microorganisms for stabilizing biological decomposable organic matter (carbonaceous) in water under aerobic condition. The test is used to determine the pollution load of waste water the degree of pollution and the efficiency of waste water treatment methods. 5–day BOD test being a bio assay procedure (involving measurement of oxygen consumed by bacteria for degrading the organic matter aerobic condition requires addition of pH and temperature and absence microbial growth inhibiting substances.

Preparation of dilution water

To 1000 ml water each of phosphate buffer magnesium sulphate calcium chloride and ferric chloride solution is added before bringing it to 20°C and aerating it thoroughly.

Procedure:

The sample having at a pH of 7 is determined for first day. Do various dilutions (at least) a prepared to obtain about 50% depletion of DO using sample and dilution water. The samples are incubated at 20°C for 5 days and the 5th day DO is noted using the ox meter. A reagent blank is also prepared in a similar manner.

Calculation: DO (5day incubator)

$$\text{BOD (mg/L)} = \frac{DO(initial) - DO(5\,days\,incubation)}{decimal\ fraction\ of\ dilution}$$

Where,

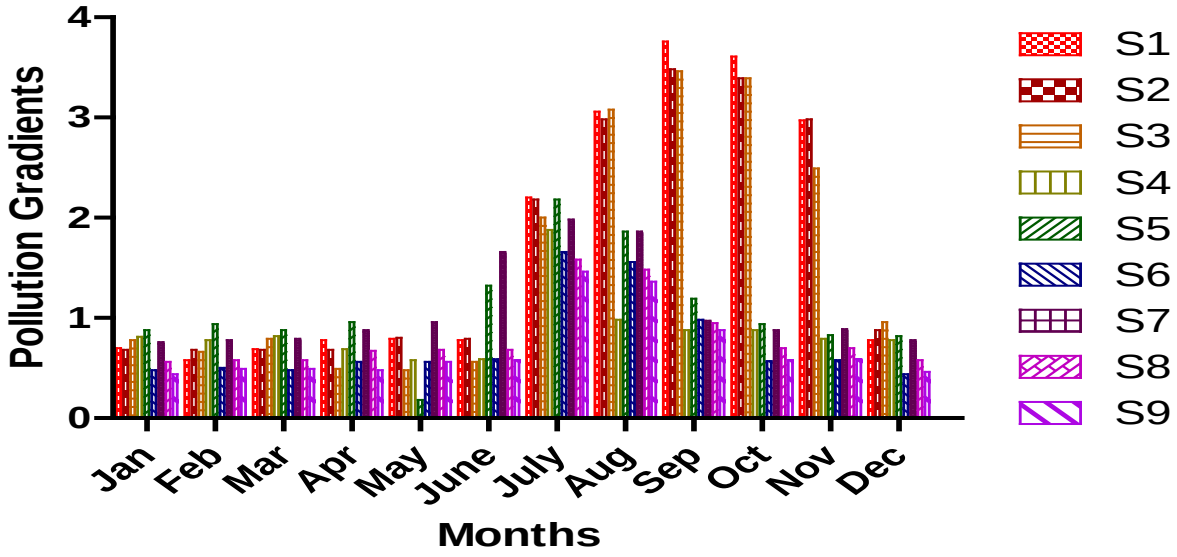
DO initial = dissolve oxygen of the sample for the first BOD bottle which is not incubated.

DO (5 days incubation) = dissolve oxygen of the sample after 5days incubation in dark.

Results and Discussion

Experimental data on Scanning (Table 1a to 1b and Figs. 1a to 7b) reveals that there are appreciable differences in odor, taste, temperature, turbidity, pH, hardness, and B.O.D pre and post confluence points of drains in Sai River, Uttar Pradesh.

Odour: During 2022 and 2023 the month wise variation of odor at different zones of Sai River has been demonstrated in Figs. 2a and 2b, respectively. The self-purification caused by river between site S_6–S_5 and S_9–S_8 during 2022 has a negative value TON per meter which becomes zero at site S_3–S_2 in October month. For the site in 2022, the self-purification gradients are negative in the months of January, April, May, July, August, September, October, November, December and positive average pollution gradient in February, March, June months. In 2023 the magnitude of self-purification becomes nil at site S_2–S_1 May, June, December site S_3–S_2 August month site S_5–S_4 August month and average negative pollution gradient January, February, March, April, July, August, September, November, December and positive average pollution gradient in month May, June and October. An insight of the total year indicates that this zone has an ideal 100% efficiency of self-purification. This may be due to less biotic contaminates more degradable pollutants and non-volatile impurities in water. The average value of pollution gradients for all the zones in all the months during 2022 has been observed negative but the same values in 2023 have a positive magnitude in the months of May, June and October.



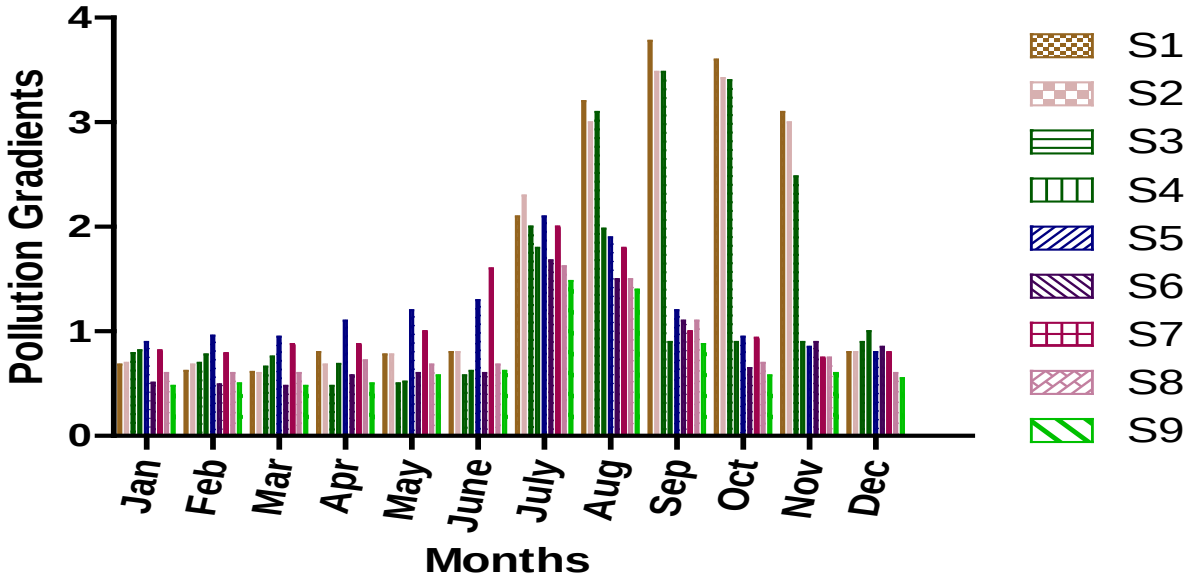


Figure 2. Month wise variation in odour (TON) at different sampling zones of Sai River at Jaunpur (a) 2022 (b) 2023

Taste: The nature of soluble impurities in river is causes the taste of river water. It is partially due to pH, biotic contaminants and temperature. During 2022, the taste of river water for all sites was found acceptable in January, February and March but in April it become unfit for sites S_4 and S_5 in may the taste was acceptable for site S_2 but unfit for all the other sites. In June the taste was bad for all the sites except S_7 which was non-acceptable in July due to large impurities from the surroundings for all sites the taste was non-acceptable. The same trend is followed in August. All the sites were alike in taste (unfit) during September and October which may attribute to high drain contribution of pollutants to the river. During November and December for all the sites the taste was acceptable due to less drain flow and low temperature. In 2023 almost the same trend has been observed making a generalization that the taste of river water becomes acceptable during winter which is non-acceptable in July, August and unfit at the tail of rainy season. A mixed behavior of acceptable, non-acceptable and unfit has been separated during summer season.

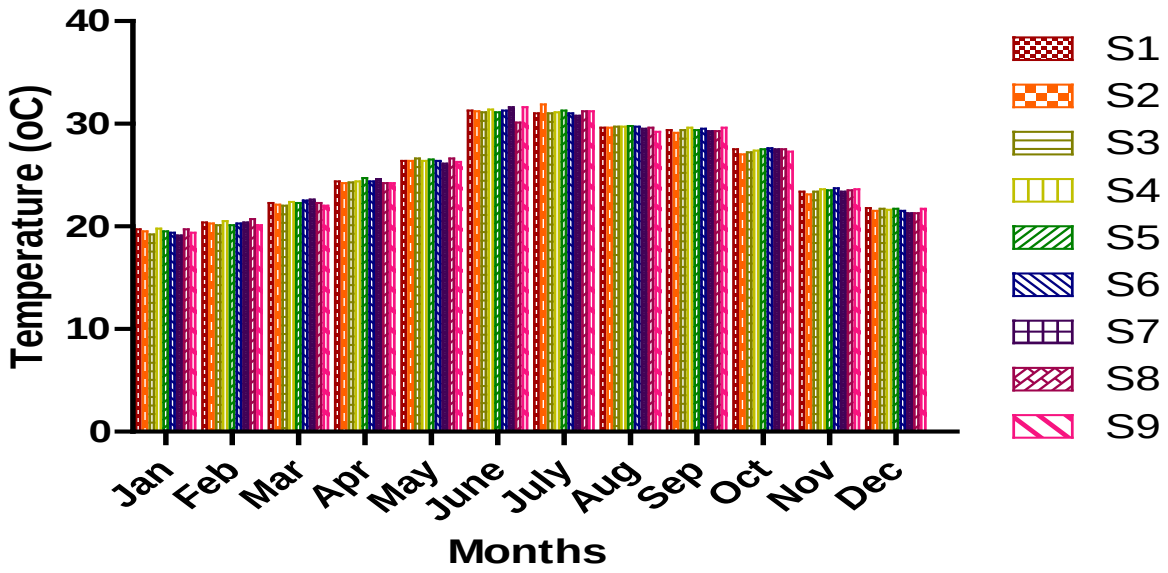
Table 1a. Month wise variation in taste at different sampling zones of Sai River at Jaunpur 2022

Month	Sites								
	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9
Jan									
Feb	a	a	a	a	a	a	a	a	a
Mar	a	a	a	a	a	a	a	a	a
Apr	a	a	a	b	b	a	a	a	a
May	b	a	b	b	b	b	b	b	b
June	b	b	b	b	b	b	c	b	b
July	c	c	c	c	c	c	c	c	c
Aug	c	c	c	c	c	c	c	c	c
Sep	b	b	b	b	b	b	b	b	b
Oct	b	b	b	b	b	b	b	b	b
Nov	a	a	a	a	a	a	a	a	a
Dec	a	a	a	a	a	a	a	a	a

Table 1b. Month wise variation in taste at different sampling zones of Sai River at Jaunpur 2023

Month	Sites								
	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9
Jan	a	a	a	a	a	a	a	a	a
Feb	a	a	a	a	a	a	a	a	a
Mar	a	a	a	a	a	a	a	a	a
Apr	a	a	a	b	b	a	a	a	a
May	b	a	b	b	b	b	b	b	b
June	b	b	b	b	b	b	c	b	b
July	c	c	c	c	c	c	c	c	c
Aug	c	c	c	c	c	c	c	c	c
Sep	b	b	b	b	b	b	b	b	b
Oct	b	b	b	b	b	b	b	b	b
Nov	a	a	a	a	a	a	a	a	a
Dec	a	a	a	a	a	a	a	a	a

Temperature: The temperature of river water is due to large quantity and fluidity has no significant effect on acceptability and applicability of water. However, the lowest temperature of zones in 2022 was observed 19.0ºC in January for zone S_7 which had the highest value of temperature 31.8ºC in July site S_2. Though the temperature variation for different sites in a particular month depends on the atmospheric temperature, shadow of the surroundings, soil character and biochemical reactions. While in year 2023 lowest temperature is observed at sites S_3 and S_7 19.1ºC in January month and highest temperature 31.8ºC at site S_2 in July month (Figs. 3a, 3b).



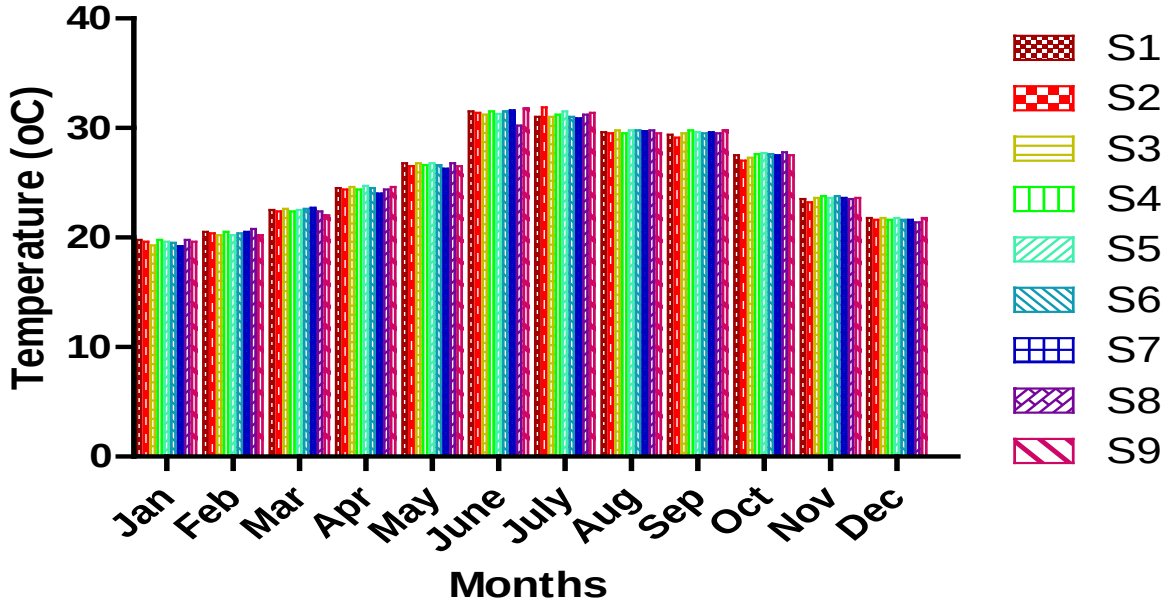
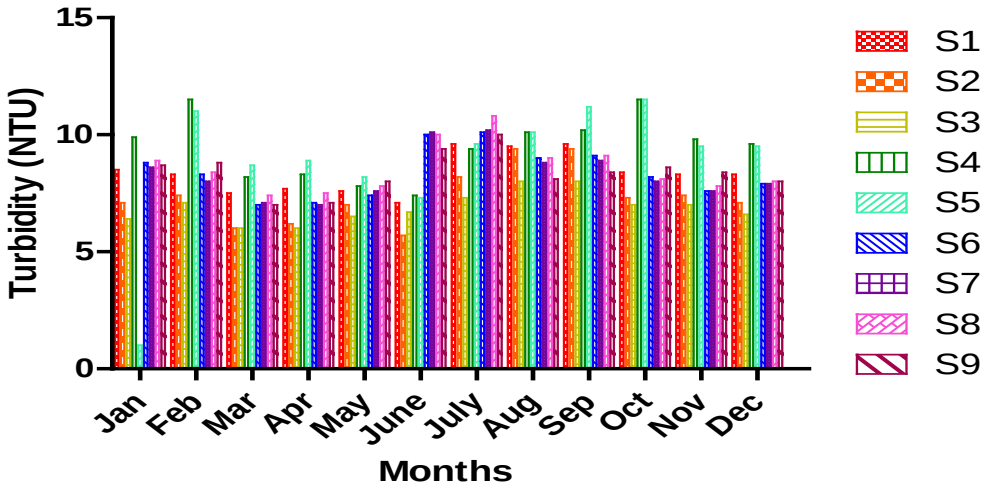


Figure 3. Month wise variation in temperature (^{o}C) at different sampling zones of Sai River at Jaunpur (a) 2022 (b) 2023

Turbidity: The dissolved materials and suspended matter especially in the colloidal state in the cause's turbidity of river water. The pollution gradients in 2022 for a sites S_2-S_1, S_3-S_2 has negative value throughout whole year and similar positive value have been observed from sites between S_4-S_3, S_8-S_7 throughout whole year and mixed phenomenon i.e., sometime positive and sometime negative and sometime zero value have been obtained. The pollution gradient in year 2023 for a zone S_2-S_1 has negative value throughout whole year and positive value between Zone S_8-S_7 and sometime positive and sometime negative and sometime zero (Figs. 4a, 4b)



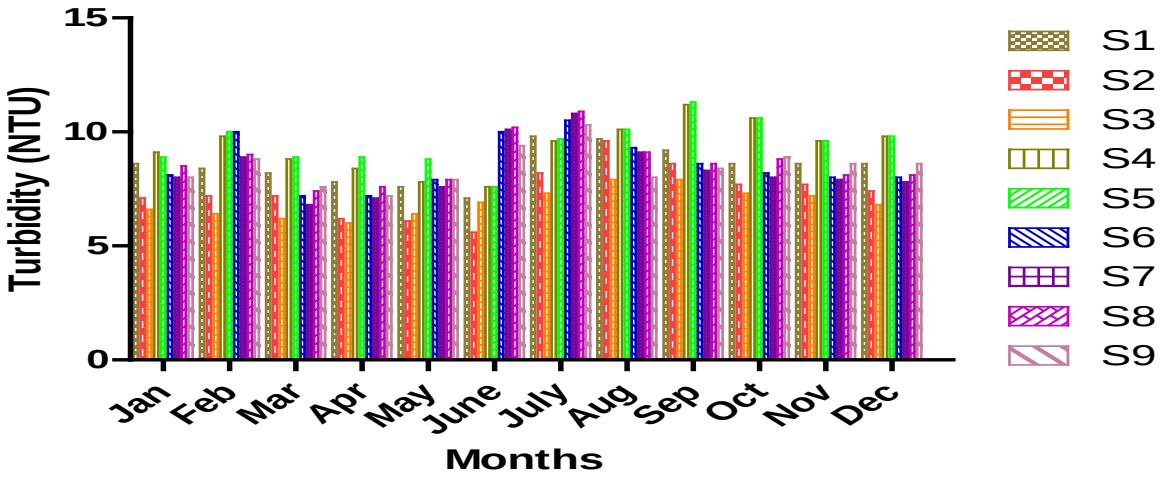
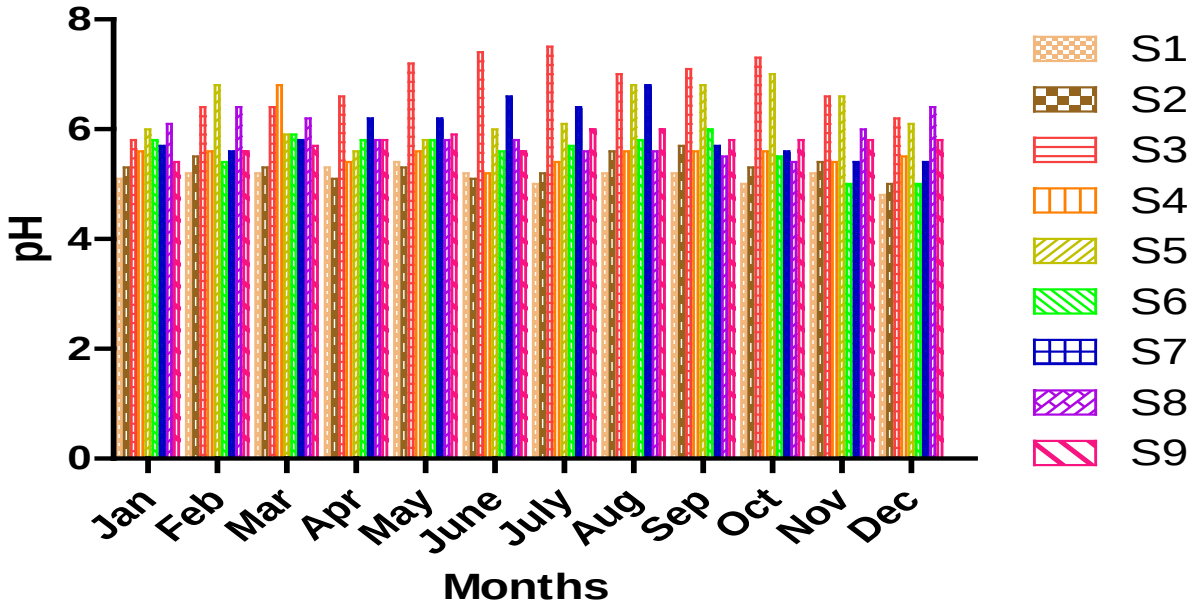


Figure 4. Month wise variation in turbidity (NTU) at different sampling zones of Sai River at Jaunpur (a) 2022 (b) 2023

pH: The magnitude of pH in river water is decided by the nature of soluble salts, their hydrolysis and biodegradation producing acids. The average pollution gradient is negative in June 2022 and positive average pollution gradient in whole month. In year 2023 the average pollution gradient is positive (Figs. 5a, 5b).



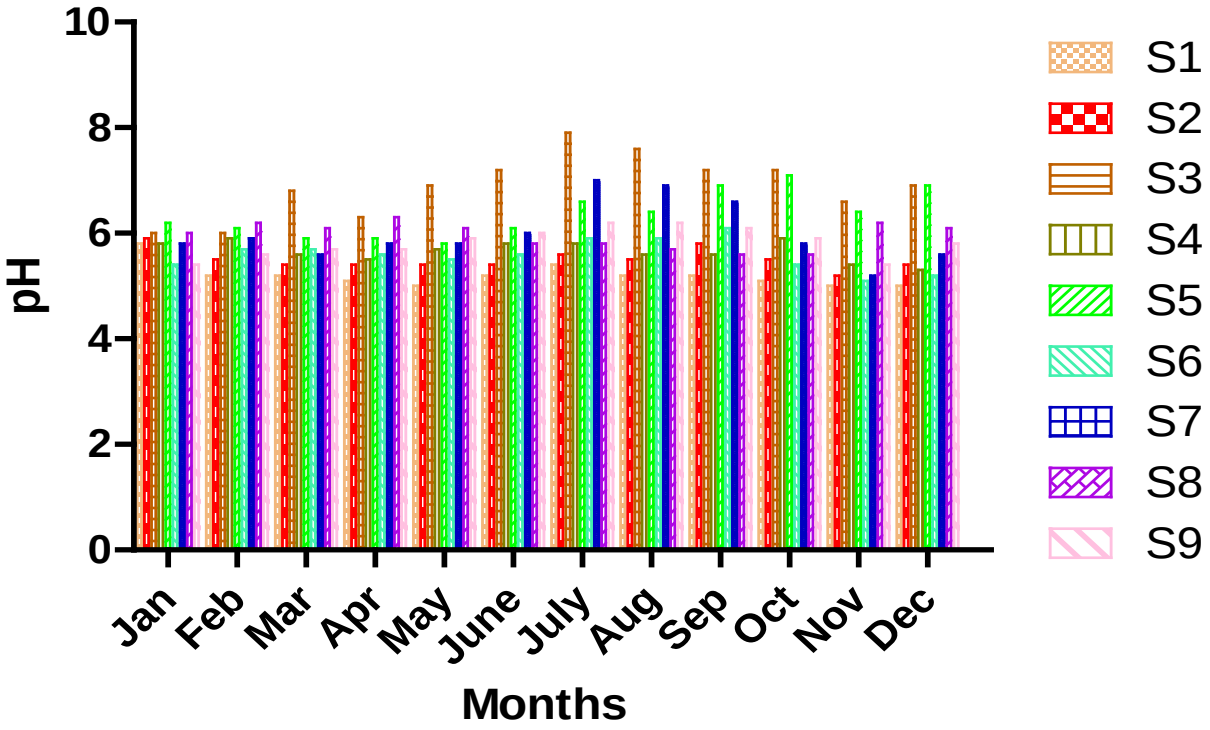


Figure 5. Month wise variation in pH at different sampling zones of Sai River at Jaunpur (a) 2022 (b) 2023

Hardness: The presence of water-soluble carbonates, bicarbonates and chlorides in river water is causes hardness. It is passing through drains. Such pollutants make river water unfit for drinking, domestic use, refrigeration and industrial purposes. The pollution gradients in 2022 between site S_1-S_2, S_2-S_3, S_3-S_4, S_4-S_5, S_5-S_6 are positive and in site S_7-S_6 positive in month January, March, April, May, July, September, November and December and negative February, June, August, October. As site S_7-S_8 negative average pollution gradient in month August, September and positive remaining month (Figs. 6a, 6b). As site S_8-S_9 negative average pollution gradient are month June and December and positive average pollution gradients remaining month. In year 2023 the average pollution gradients are positive in whole year.

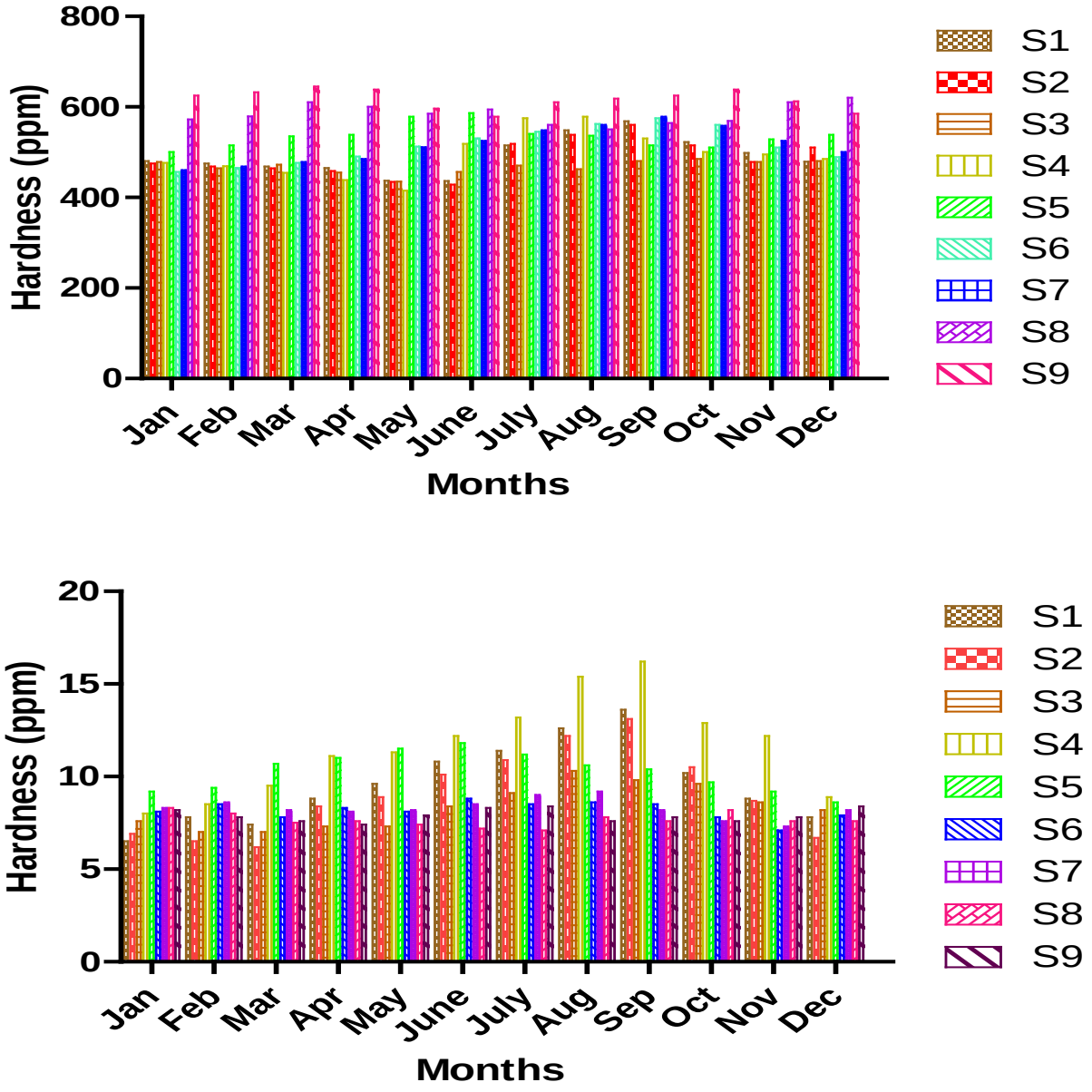


Figure 6.Month wise variation in hardness (ppm) at different sampling zones of Sai River at Jaunpur (a) 2022 (b) 2023

Biological Oxygen Demand: The concentration of biotic contaminants the B.O.D. of river water, which may undergo oxidation in water. A high B.O.D affects its odor, pH and other parameters to large extents. In year 2022 positive average pollution gradients observed in month April, July,October, November, December while the negative average pollution gradients exhibited by the month of this year. In year 2023 the average pollution gradient in month January, February, March, May, June, July, September, December is negative while in month April, August, October, November positive average pollution gradients observed (Figs. 7a, 7b).

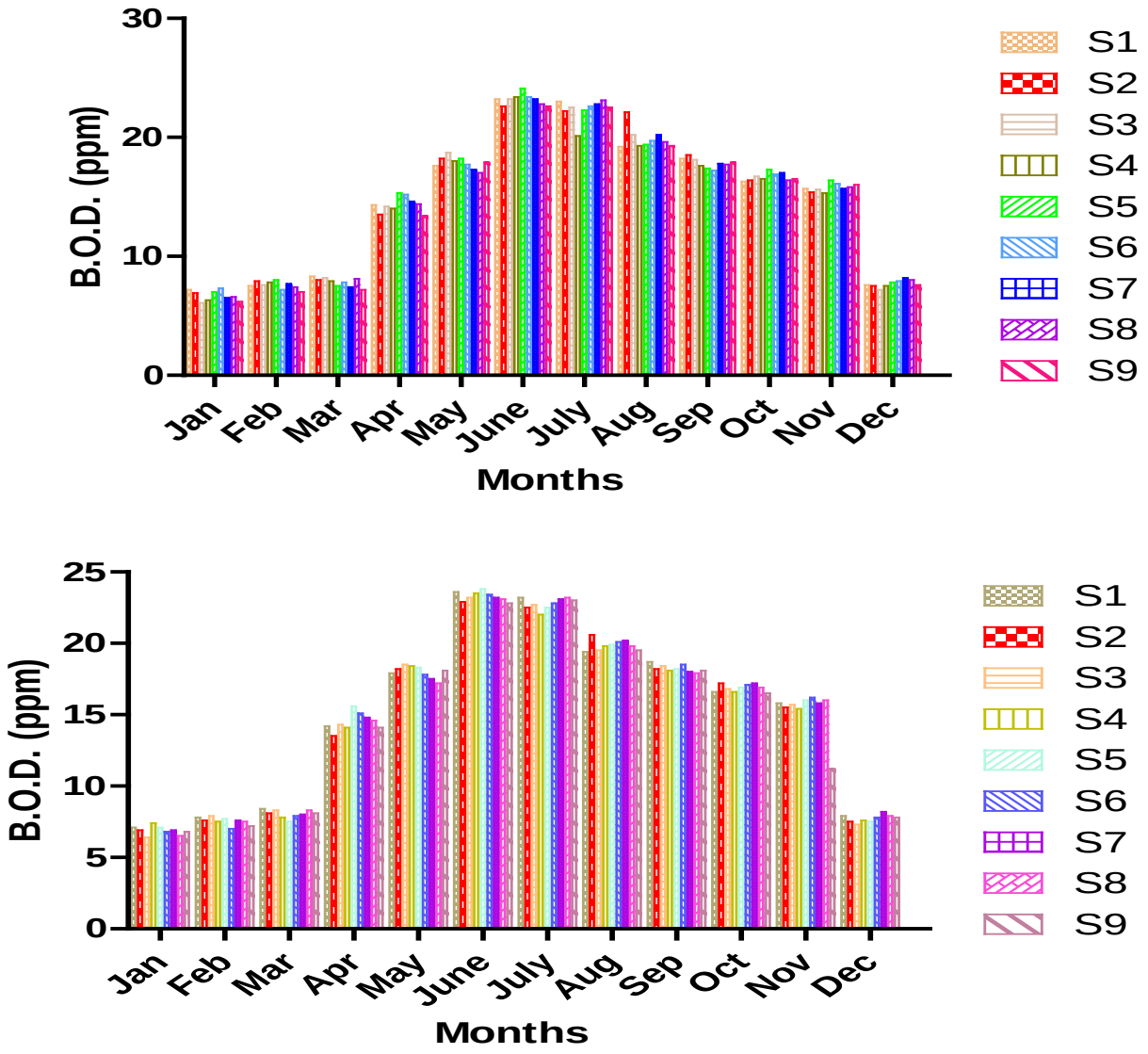


Figure 7. Month wise variation in B.O.D. (ppm) at different sampling zones of Sai River at Jaunpur (a) 2022 (b) 2023

Conclusions

Though the studied process of self-purification in the proposed research is natural, yet, it will give a clue for the artificial purification of polluted water by adsorption technique. Moreover, the study will provide possibilities to enhance the purification efficiency by supplementing the bed-rock with some additional materials. In some places where self-purification phenomenon is extremely slow the bed deposits in the river may be removed off and replaced by better, cheap absorbents. The self-purification study including bed-rocks, vegetation and aquatic animals may innovate new materials employed for the water purification process.

References

Aggrawal, V., T. Dikid, S. K. Jain, A. Pandey, P. Khasnobis, S. Choudhary & S. K. Singh 2020. Disease surveillance during a large religious mass gathering in India: The Prayagraj Kumbh 2019 experience. *International Journal of Infectious Diseases*, **101:** 167-173.

Akoto, O., A. Adopler, H. E. Tepkor & F. Opoku 2021. A comprehensive evaluation of surface water quality and potential health risk assessments of Sisa river, Kumasi. *Groundwater for Sustainable Development,***15:** 100654.

Batabyal, A. A. 2023. Tanneries in Kanpur and pollution in the Ganges: A theoretical analysis. *Regional Science Policy & Practice*, **15(5):** 1114-1123.

Bowes, M. J., D. S. Read, H. Joshi, R. Sinha, A. Ansari, M. Hazra & H. G. Rees 2020. Nutrient and microbial water quality of the upper Ganga River, India: identification of pollution sources. *Environmental Monitoring and Assessment*, **192:** 1-20.

Carvalho, I. T. & L. Santos 2016. Antibiotics in the aquatic environments: a review of the European scenario. *Environment International*, **94:** 736-757.

Chatanga, P., V. Ntuli, E. Mugomeri, T. Keketsi & N. V. Chikowore 2019. Situational analysis of physico-chemical, biochemical and microbiological quality of water along Mohokare River, Lesotho. *The Egyptian Journal of Aquatic Research*, **45(1):** 45-51.

Chen, X., L. Lei, S. Liu, J. Han, R. Li, J. Men & L. Zhu 2021. Occurrence and risk assessment of pharmaceuticals and personal care products (PPCPs) against COVID 19 in lakes and WWTP-river-estuary system in Wuhan, China. *Science of the Total Environment*, **792:** 148352.

Chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/https://cpcb.nic.in/wqm/BIS_Drinking_Water_Specification.pdf 468

Dong, Y., Y. Li, F. Kong, J. Zhang & M. Xi 2020. Source, structural characteristics and ecological indication of dissolved organic matter extracted from sediments in the primary tributaries of the Dagu River. *Ecological Indicators*, **109:** 105776.

Dutta, V., D. Dubey & S. Kumar 2020. Cleaning the River Ganga: Impact of lockdown on water quality and future implications on river rejuvenation strategies. *Science of the Total Environment*, **743:** 140756.

Dwivedi**,** A. C., A. S. Mishra, P. Mayank & A. Tiwari 2016b. Persistence and structure of the fish assemblage from the Ganga river (Kanpur to Varanasi section), India. *Journal of Geography and Natural Disasters*, **6:** 159. **Doi:** 10.4172/2167-0587.1000159.

Dwivedi, A. C., A. Tiwari and P. Mayank (2018). Environmental pollution supports to constancy and invader potential of *Cyprinus carpio* and *Oreochromis niloticus* from the Ganga river, India. *International Journal of Poultry and Fisheries Sciences*, **2(1):** 1-7.

Dwivedi, A.C., P. Mayank & A. Tiwari 2016a. The River as transformed by human activities: the rise of the invader potential of *Cyprinus carpio* and *Oreochromis niloticus* from the Yamuna River, India. *Journal of Earth Science & Climatic Change*, **7(7):** 361. doi: 10.4172/2157-7617.1000361.

Dwivedi, S., P. S. Chauhan, S. Mishra, A. Kumar, P. K. Singh, M. Kamthan & C. S. Nautiyal 2020. Self-cleansing properties of Ganga during mass ritualistic bathing on Maha-Kumbh. *Environmental monitoring and assessment*, **192:** 1-15.

Gupta, S., D. W. Graham, T. R. Sreekrishnan & S. Z. Ahammad 2023. Exploring the impacts of physicochemical characteristics and heavy metals fractions on bacterial communities in four rivers. *Journal of Environmental Management*, **325:** 116453.

Hirapara, P., M. L. Gaur, G. R. Patel, M. K. Tiwari & M. M. Trivedi 2022. Hydro-morphological characteristics in relation to soil conservation planning of Hathamati watershed. *Journal of Soil and Water Conservation*, **21(3):** 233-240.

https://cpcb.nic.in/water-quality-criteria/

https://nmcg.nic.in/NamamiGanga.aspx

https://www.who.int/publications/i/item/9789241565486

Jadhav, H.V. & S.H. Purohit 2008. Global pollution and environmental monitoring. Himalaya Publishing House-8184880170, 9788184880175-315 pages.

Jaiswal, D. & J. Pandey 2019. Anthropogenically enhanced sediment oxygen demand creates mosaic of oxygen deficient zones in the Ganga River: Implications for river health. *Ecotoxicology and Environmental Safety*, **171:** 709-720.

Kanaujiya, A. K. & V. Tiwari 2023. Water quality analysis of River Ganga and Yamuna using water quality index (WQI) during Kumbh Mela 2019, Prayagraj, India. *Environment, Development and Sustainability,* 1-22.

Kishor, R., D. Purchase, G. D. Saratale, R. G. Saratale, L. F. R. Ferreira, M. Bilal & R. N. Bharagava 2021. Ecotoxicological and health concerns of persistent coloring pollutants of textile industry wastewater and treatment approaches for environmental safety. *Journal of Environmental Chemical Engineering*, **9(2):** 105012.

Kulkarni, A. D. 1973. The thermodynamic studies of liquid copper alloys by electromotive force method: Part I. The Cu− O, Cu− Fe− O, and Cu− Fe systems. *Metallurgical Transactions*, **4(7):** 1713-1721.

Kumar, A., A. K. Taxak, S. Mishra & R. Pandey 2021. Long term trend analysis and suitability of water quality of River Ganga at Himalayan hills of Uttarakhand, India. *Environmental Technology & Innovation*, **22:** 101405.

Kumar, A., S. Mishra, A. K. Taxak, R. Pandey & Z. G. Yu 2020. Nature rejuvenation: Long-term (1989–2016) vs short-term memory approach-based appraisal of water quality of the upper part of Ganga River, India. *Environmental Technology & Innovation*, **20:** 101164.

Kumar, D., D. S. Malik, N. Kumar, N. Gupta & V. Gupta 2020. Spatial changes in water and heavy metal contamination in water and sediment of river Ganga in the river belt Haridwar to Kanpur. *Environmental Geochemistry and Health*, **42:** 2059-2079.

Mariya, A., C. Kumar, M. Masood & N. Kumar 2019. The pristine nature of river Ganges: its qualitative deterioration and suggestive restoration strategies. *Environmental Monitoring and Assessment*,**191(9):** 542.

Mayank, P. & A. C. Dwivedi 2015. River health and commercially important catfishes from the Yamuna river, India. *Journal of the Kalash Science*, **3(3, Special Volume):** 23-26.

Misra, A. K. 2011. Impact of urbanization on the hydrology of Ganga Basin (India). *Water Resources Management*, **25:** 705-719.

Mohanty, T. R., N. K. Tiwari, B. K. Das, H. S. Swain, C. Jhonson & T. Banerjee 2023. Riverine connectivity influences the phytoplankton ecology in the open floodplain wetland of the lower river Ganga. *Environmental Monitoring and Assessment*, **195(12):** 1403.

Muduli, P. R., A. Kumar, V. V. Kanuri, D. R. Mishra, P. Acharya, R. Saha & A. Sudhakar 2021. Water quality assessment of the Ganges River during COVID-19 lockdown. *International Journal of Environmental Science and Technology*, **18:** 1645-1652.

Munawar, M., M. Fitzpatrick & I. F. Munawar 2022. Application of the Laurentian Great Lakes 'Ecosystem Approach 'towards remediation and restoration of the mighty River Ganges, India. *Aquatic Ecosystem Health & Management*, **25(2):** 1-14.

Naik, S., K. M. Purohit & R. N. Patel 1996. Complexes of Cu (II), Ni (II) and Co (II) with Schiff Base Derived from Salicylaldehyde and o-Aminophenol with Some Neutral Donor Ligands. *Asian Journal of Chemistry*, **8(3):** 560.

Purohit, M., V. Diwan, V. Parashar, A. J. Tamhankar & C. S. Lundborg 2020. Mass bathing events in River Kshipra, Central India-influence on the water quality and the antibiotic susceptibility pattern of commensal *E. coli*. *Plos one*, **15(3):** e0229664.

Quadri, S. A. & P. R. Padala 2021. An aspect of Kumbh Mela massive gathering and COVID-19. *Current Tropical Medicine Reports*, **8:** 225-230.

Rad, S. M., A. K. Ray & S. Barghi 2022. Water pollution and agriculture pesticide. *Clean Technologies*, **4(4):** 1088-1102.

Raman, R. K., M. Bhor, R. K. Manna, S. Samanta & B. K. Das 2023. Statistical and geostatistical modeling approach for spatio-temporal assessment of river water quality: a case study from lower stretch of River Ganga. *Environment, Development and Sustainability*, **25(9):** 9963-9989.

Rao, N. S., A. Dinakar & L. Sun 2022. Estimation of groundwater pollution levels and specific ionic sources in the groundwater, using a comprehensive approach of geochemical ratios, pollution index of groundwater, unmix model and land use/land cover–A case study. *Journal of Contaminant Hydrology*, **248:** 103990.

Reddy, B., J. Pandey & S. K. Dubey 2019. Assessment of environmental gene tags linked with carbohydrate metabolism and chemolithotrophy associated microbial community in River Ganga. *Gene*, **704:** 31-41. 535.

Rice, Eugene W., Laura Bridgewater, and American Public Health Association, eds. Standard methods for the examination of water and wastewater. Vol. 10. Washington, DC: American public health association, 2012.

Sharma, P. & A. Kaushik 2023. Riverine water quality engendered by policy interventions, episodic socio-cultural activities, and the COVID-19 pandemic lockdown: A case study of upper and middle Ganga, India. *International Journal of Geography, Geology and Environment*, **5(1):** 15-24.

Su, Z., K. Wang, F. Yang & T. Zhuang 2023. Antibiotic pollution of the Yellow River in China and its relationship with dissolved organic matter: Distribution and Source identification. *Water Research*, **235:** 119867.

Subba Rao, N. 2021. Spatial distribution of quality of groundwater and probabilistic non-carcinogenic risk from a rural dry climatic region of South India. *Environmental Geochemistry and Health*, **43(2):** 971-993.

Tariq, A. & A. Mushtaq 2023. Untreated wastewater reasons and causes: a review of most affected areas and cities. *Int. J. Chem. Biochem. Sci*, **23:** 121-143.

Tiwari, A., A. C. Dwivedi& P. Mayank 2016. Time scale changes in the water quality of the Ganga River, India and estimation of suitability for exotic and hardy fishes. *Hydrology Current Research*, **7(3):** 254. doi:10.4172/2157-7587.1000254.

Tripathi, S., A. Gopesh &A. C. Dwivedi 2017. Framework and sustainable audit for the assessing of the Ganga river ecosystem health at Allahabad, India. *Asian Journal of Environmental Science*, **12(1):** 37-42. DOI: 10.15740/HAS/AJES/12.1/37-42.

Wang, C., C. Zhang, Y. Wang, G. Jia, Y. Wang, C. Zhu & X. Zou 2022. Anthropogenic perturbations to the fate of terrestrial organic matter in a river-dominated marginal sea. *Geochimica et Cosmochimica Acta*, **333:** 242-262.

Zhang, L., G., Fu & Z. Zhang 2019. High-efficiency salt, sulfate and nitrogen removal and microbial community in biocathode microbial desalination cell for mustard tuber wastewater treatment. *Bioresource Technology*, **289:** 121630.

Zhang, L., Q. Sun, Q. Dou, S. Lan, Y. Peng & J. Yang 2022. The molecular characteristics of dissolved organic matter in urbanized river sediments and their environmental impact under the action of microorganisms. *Science of The Total Environment*, **827:** 154289.