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Water Quality Testing of Yamuna River at Poiya Ghat (Vaikunth Dham / Swarg Dham), Agra

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Since pre-historic times, river water has been used as a source of drinking water. River water is now a source of hydropower generation, irrigation, aquaculture, navigation, transportation, and supports socio-economic activity, human settlement and aquatic living forms. Apart from this, river water has a very vital role in maintaining soil fertility, wildlife conservation and development of forest resources. Due to increase in industrialization, urbanization, mining, sewage disposal and rampant use of technology, Yamuna River water is becoming polluted day by day. It is threatening the survival of life itself. Due to use of contaminated water, human population suffers from water borne diseases. Water quality is getting affected by organic, inorganic and biological pollutants discharged from industrial effluents, domestic waste and sewage. The problem of pollution in Yamuna River has reached alarming proportions. The present study focuses on physico-chemical analysis of Yamuna River water at Poiya Ghat site, Agra to determine its quality and pollution profile over a

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period of 8 months. The dangerous values of parameters like Total Hardness, high concentration of TDS, Fluoride content, BOD and COD and presence of heavy metals like Pb, Al and Fe beyond the WHO and BIS permissible limits for drinking water is a cause for alarm. The present study shows the need for a continuous pollution monitoring and treatment programme of Yamuna river water in India. Government should focus on the control of point sources as well as non-point sources of pollution by initiating different programmes like Yamuna Action Plan (YAP) for the improvement of water quality of Yamuna River and restore it as a pious river once again.

Keywords: Yamuna River; water quality parameters; water pollution; permissible limits.

1. INTRODUCTION

River plays a very crucial role in lives of Indian people because of its importance in sustenance of life and it has its due importance in Indian religious customs. There are thousands of rivers in India. River Yamuna is one of the longest tributaries of River Ganges. It is about 1370 km long [1]. In Uttar Pradesh it covers Kairan, Baghpat, Noida, Mathura, Agra, Firozabad, Etawah, Auraiya and Allahabad.

As it is covering most of the northern part of India, thousands of people are dependent on River Yamuna for their household needs, as well as industrial and other purposes. About 85% of human population relies upon the groundwater for drinking [2,3]. Daily discharge domestic waste, sewage waste, settlements, agriculture and industrial effluents are deteriorating the water quality of River Yamuna. According to Central Pollution Control Board (CPCB) data Yamuna river water comes under the "E" Category that means it is only useful for irrigation and industrial cooling or controlled waste disposal [4,5,1].

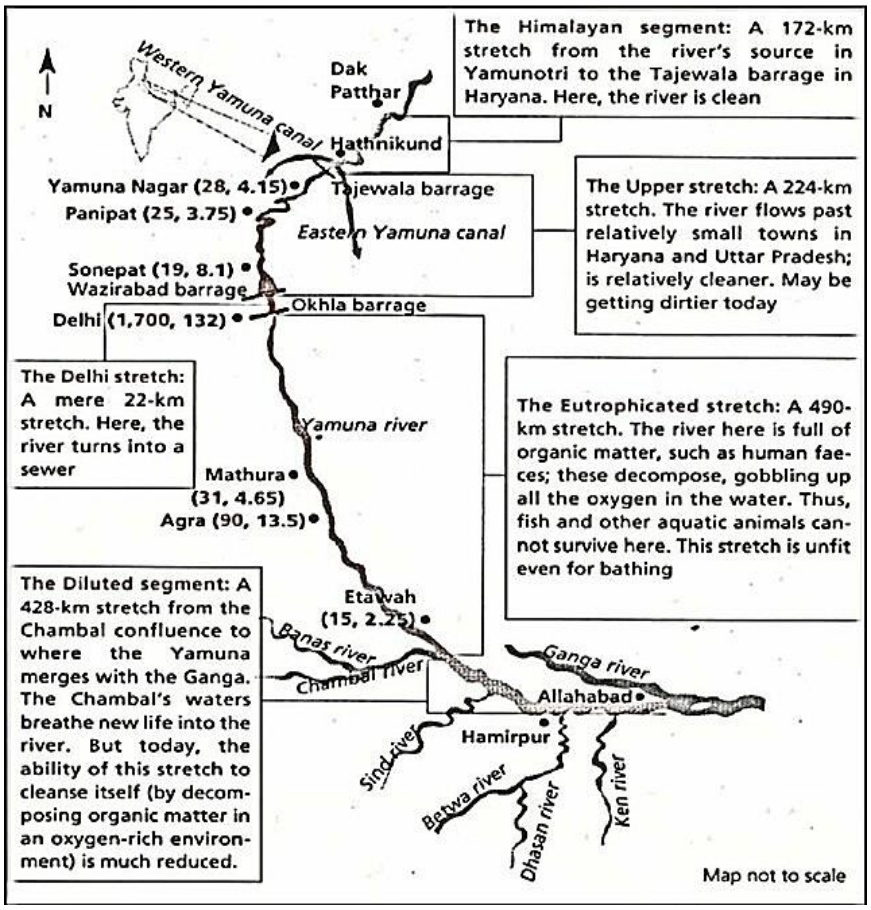


Fig. 1. Map of Yamuna River across the India

In Agra, the main source contributing to pollution of Yamuna River water could be discharge of effluents from Petha and Leather industries. Rout and other groups studied some physico-chemical parameters of the Yamuna River water from four different stations of Agra city, from May to October 2014. EC, TDS and turbidity were found to be above the permissible limit of BIS. Yamuna River water of Agra is highly polluted and was not suitable for human use [6-8]. Singh et al. carried out statistical assessment using correlation coefficient and ANOVA method of water quality parameters at six different sites of Yamuna river of Mathura- Agra region. A significant positive correlation was observed amongst temperature - pH, total hardness - total alkalinity, dissolved oxygen - total suspended solids, chemical oxygen demand - electrical conductivity and electrical conductivity – total alkalinity and EC, TSS, Total Hardness, Nitrate, Alkalinity, BOD, chloride and COD and phosphate. All parameters exceeded the permissible limits of WHO and BIS [9,10-12,13]. Parween and others assessed water quality of Yamuna River at Delhi Region. Conductivity, salinity and sodium content were found within the acceptable levels of drinking water guidelines but chloride, nitrate, and total phosphate concentrations exceeded the acceptable level of water quality standards. Al, Co, Cr, Cd, Fe, Pb, Mn and Ni concentrations were found above the acceptable limits of BIS [14-16,11]. Sharma et al. studied physiochemical parameters like pH, BOD, COD, Total Coliform, Temperature, DO, Alkalinity, Chlorides, Calcium, Magnesium, and Hardness as Calcium Carbonate and TDS of Yamuna River at Dehradun on monthly basis for 2017, 2018 and 2019 through mathematical model. Parameters like Temperature, TDS, Total coliform and Hardness increased yearly, while pH and DO did not [17,18]. Singh et al. studied the impact of COVID-19 lockdown period on the water quality of Yamuna River. The water quality parameters such as pH, EC, TSS, BOD, and COD were found to have improved during lockdown compared to the pre-lockdown period in 2019 because of the low effluent discharge [19,10].

The extensive literature survey done on the topic reflects that for the healthier and wealthier livelihood, the regular monitoring of river water quality is essential [20-35]. Since Yamuna river water at Poiya Ghat (Vaikunth Dham) site of Agra is not only a source of irrigation, but also used by industries as well as for bathing, immersion of idols and ashes after the cremation of dead bodies for the nearby villagers. This sacred river is now one of the most polluted rivers in India with its water contaminated at an alarmingly high level and is not even fit to take bath or use for drinking purposes. The fertile banks of the river are also utilized for agricultural activities like growing vegetables and cultivating crops. Its contaminated water is a health hazard even in terms of contaminated vegetables, food and fruit grown in its basin. The problem of pollution in Yamuna River not only prevails but has also reached an alarming plight [19,26,31]. This alarming pollution / contamination of the river Yamuna has led to initiatives such as Yamuna Action Plan (YAP) by the Government of India. The present study had its aim to monitor the water quality parameters of Yamuna river water at Poiya Ghat (Vaikunth Dham) site of Agra over a period of 8 months regularly.

2. METHODOLOGY

2.1 Sample Collection

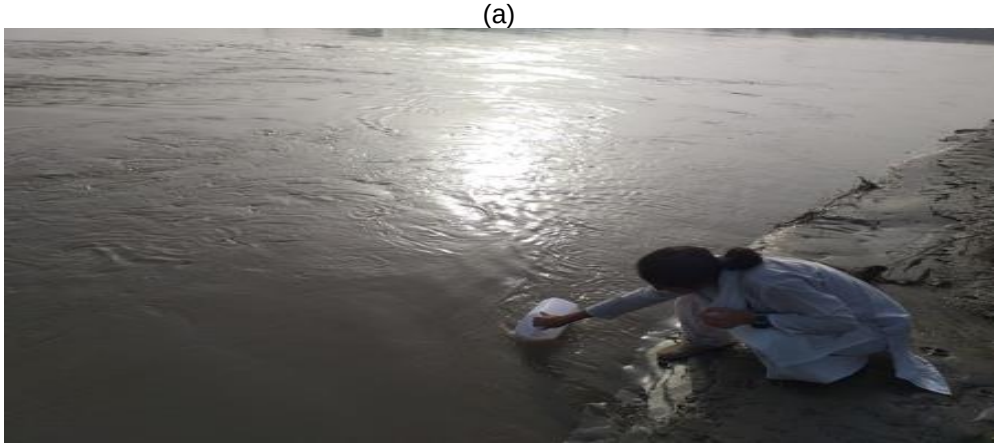
The sampling in the present study was done using a purposive and random sampling method. Yamuna River water samples were collected randomly at three different sites for a duration of 8 months i.e., from April 2023 to November 2023. On site measurements were carried out for pH of the river water. Other parameters were measured immediately after the samples were collected.

Standard protocols for water testing were followed. Detailed experimental procedure has been given for the testing of water quality parameters [11,12,17,32,33]. Replication was done with each sample to avoid errors and to obtain accurate results.

Different water quality parameters were measured are:

Parameters	**Time Period** (**April 2023-November 2023)**
pH	Weekly
Electrical Conductivity	Weekly
Chloride Content	Weekly
Fluoride Content	Weekly
Total Hardness	Weekly
Dissolved Oxygen	Weekly
Biological Oxygen Demand	Fortnightly
Chemical Oxygen Demand	Fortnightly
Total Dissolved Solid	Weekly
Heavy Metals	Monthly

(a)



(b)

Fig. 2 (a and b): Yamuna River Water Sample collection site at Agra

3. RESULTS AND DISCUSSION

Various physico- chemical water quality parameters were measured for water quality testing of Yamuna River water at Poiya Ghat (Vaikunth Dham) site of Agra over a period of 8 months regularly. On site measurement of pH of Yamuna River water was done on weekly basis.

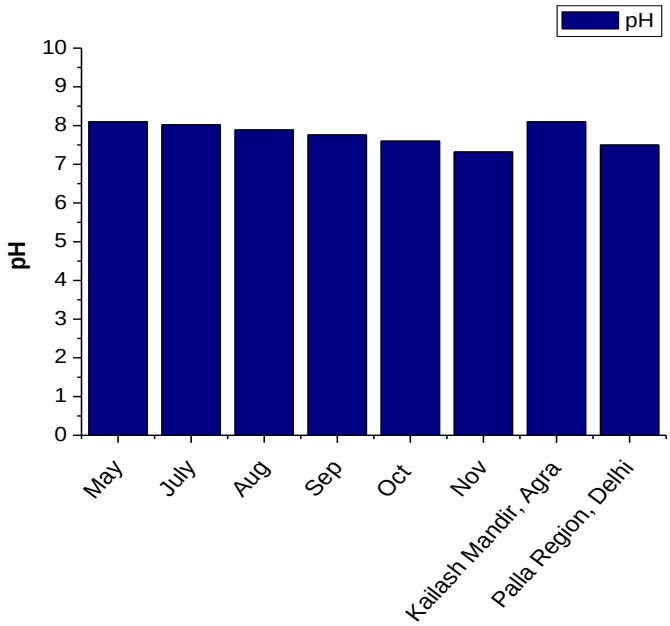


Fig. 3. Trend of pH level in respective months

The pH of river water sample was found in the range 7.3-8.1 which was under the WHO and BIS permissible limits i.e. 7.5-8.5 and was also in the same range as for Kailash Mandir, Agra and Palla Region, Delhi, which is one of the most polluted site of Delhi [5,26,31]. The river was slightly basic in the month of May with pH 8.1. With the decrease in temperature in the month of October and November, pH started decreasing as there is a positive correlation between pH and temperature of water (Fig. 3 and Table 1).

The electrical conductance (EC) of river water sample was 1300 µS/cm in the month of May (in the pre monsoon season) and started increasing in the month of July 1500 µS/cm (during monsoon) (Table 1). The value of EC increased in the month of August, September, October and November as the temperature starts decreasing in the post-monsoon season. These values are higher than Kailash Mandir, Agra where the EC was about 1100 µS/cm but it was in same range as in Palla Region, Delhi [5,26,31]. EC of samples are under the permissible limits of WHO and BIS.

Total Hardness which is the measure of carbonates and bicarbonates in water, came out to be in range of 189- 289 mg/L (Table 1), which was higher than the WHO permissible limits i.e. 100 mg/L in every month from May to November but below the BIS limits i.e. 300mg/L (Fig. 4). Total Hardness started increasing in the months of October and November i.e. in the post-monsoon period. Total Hardness of Yamuna River water at Poiya Ghat site was same as in Kailash Mandir, Agra and Palla Region, Delhi [5,26,31].

Total Dissolved Solid (TDS) which is a measure of the dissolved combined content of all organic and inorganic substances, was observed in the range of 300-420 mg/L (Table 1) at the Poiya Ghat site. It was above the permissible limits of WHO i.e. 300 mg/L and below the permissible limit of BIS i.e. 500mg/L for every month (Fig. 6). It was found that as the temperature decreases in the winter season, TDS started increasing as the river water flow was low in post-monsoon season than in monsoon season and pre-monsoon season. The TDS values of Poiya Ghat site were lower than the Kailash Mandir, Agra and Palla Region, Delhi [5,26,31].

The chloride level of Yamuna River water at Poiya Ghat was found under the permissible limits of WHO and BIS for every month i.e. 250 mg/L (Fig. 7, Table 1). Chloride level was higher in the post- monsoon season in comparison to monsoon and pre- monsoon season and was found in the same range as in Kailash Mandir, Agra and Palla Region, Delhi [5,26,31].

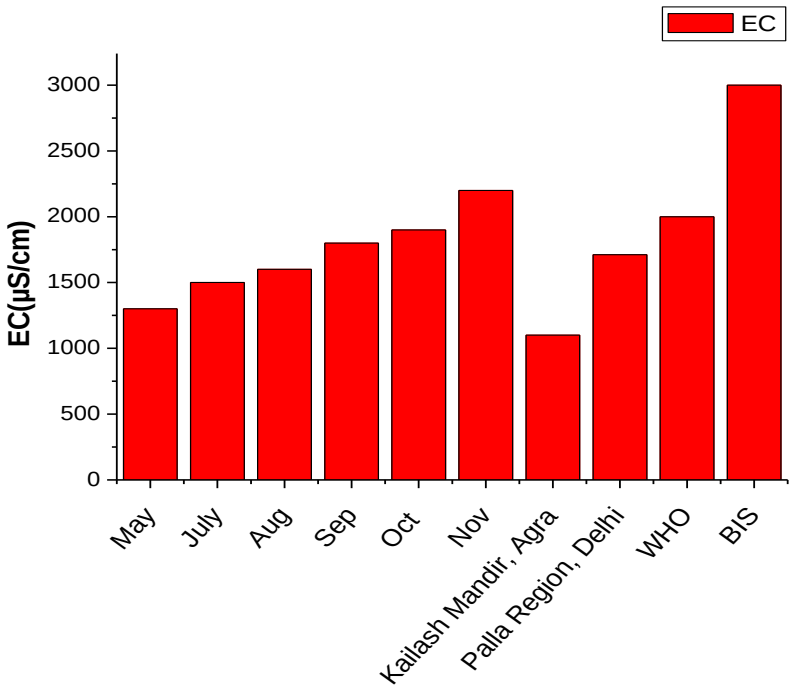


Fig. 4. Trend of EC level in respective months

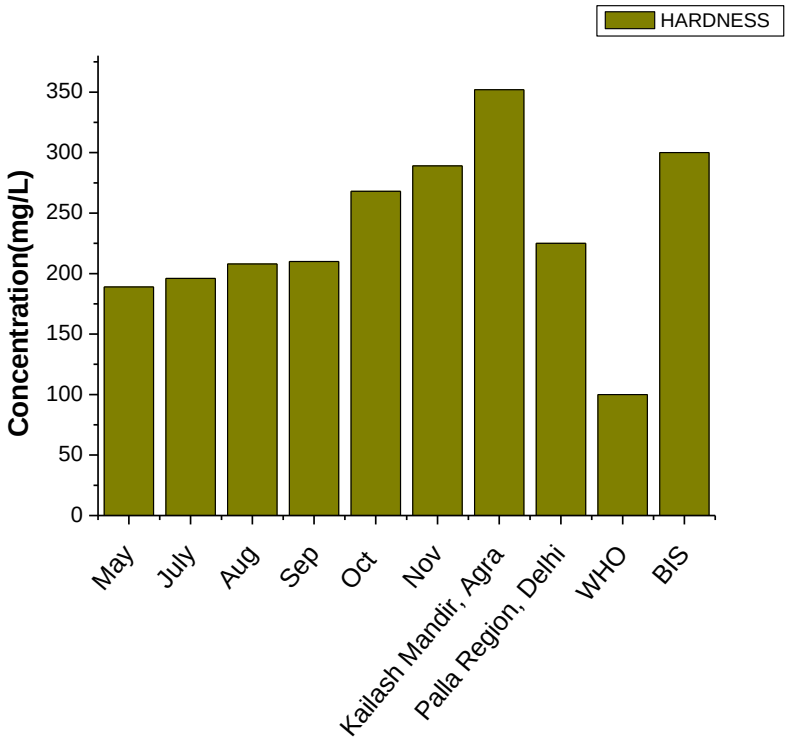


Fig. 5. Trend of Hardness level in respective months

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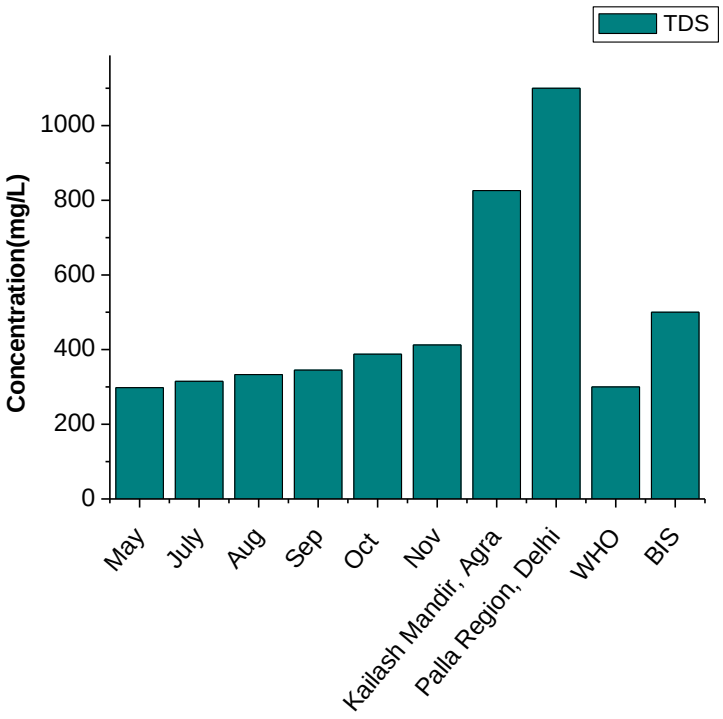

Fig. 6. Trend of TDS level in respective months

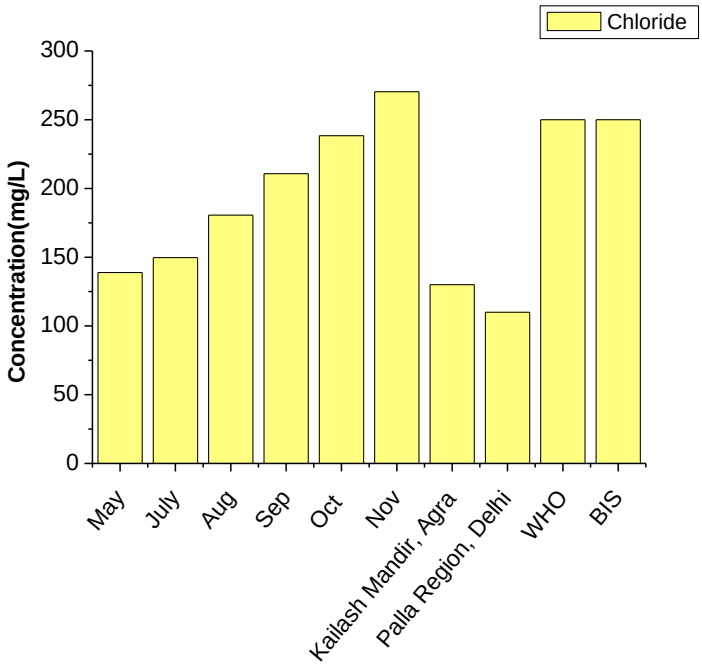

Fig. 7. Trend of Chloride level in respective months

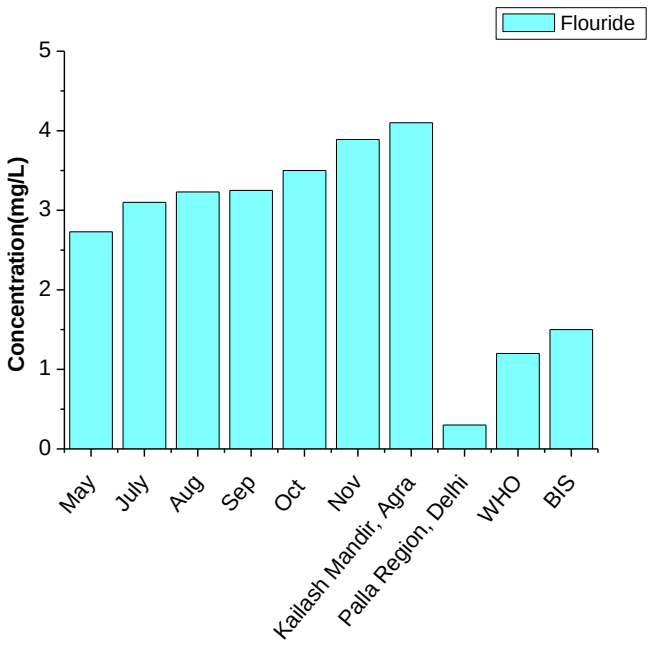

Fig. 8. Trend of Fluoride level in respective months

As shown in Fig. 8, fluoride content of Poiya Ghat site was found to be much higher and was above the permissible limits of WHO and BIS (Table 1). It was because of the presence of rocks containing fluoride in the whole Agra region from where fluoride leaches out and gets

dissolved in the river water and increases the fluoride content in the Yamuna river of Agra region. Fluoride content was higher in the post-monsoon season in comparison to the monsoon season and the pre- monsoon season. Fluoride content of Yamuna River water at Poiya Ghat site was same as in Kailash Mandir, Agra but was higher than the Palla Region, Delhi [5,26,31].

As shown in Fig. 9, Dissolved Oxygen (DO) of Yamuna river at Poiya Ghat site was slightly higher in the month of May and July but started decreasing in other months specially in post-monsoon season (Table 1) but it was within the WHO and BIS permissible limit. The dissolved oxygen (DO) values of Yamuna river water at Poiya Ghat site were in the same range as in Kailash Mandir, Agra and Palla Region, Delhi. Biological Oxygen Demand (BOD) was above the permissible limits of WHO and BIS in all the months and this shows increase in pollution in the Yamuna River at Poiya Ghat site. The BOD was also observed high in the post- monsoon season than in monsoon season because of the decrease of flow current of river water in the post- monsoon season. The BOD values at Poiya Ghat river site were in the same range as in Kailash Mandir, Agra but lower than the Palla Region, Delhi [5,26,31] (Table 1).

As shown in Fig. 9, Chemical Oxygen Demand (COD) was higher than the permissible limits of WHO and BIS in all the months and shows an increasing curve as the temperature of water decreased in the post- monsoon season (Table 1). COD values at Poiya Ghat river site were in the same range as in Kailash Mandir, Agra and Palla Region, Delhi [5,26,31]. Higher COD values shows an increase in pollution in Yamuna River at Poiya Ghat site of Agra.

Estimation of heavy metal concentration of the Poiya Ghat Yamuna water was done on monthly basis using Agilent, ICP-OES- 5110 ICP-OES.

The concentration of Zn was 0.2 mg/L in the month of May and was slightly higher in other months (Fig. 11, Table 2) but under the permissible limits of WHO and BIS [13] and shows no risk to river water quality. Hence Zn is not a significant source of pollution of Yamuna River water at Poiya Ghat site, Agra.

The Pb concentration was found to be very high in the post monsoon season and was above the WHO and BIS permissible limits for the river water [13] (Fig. 12 and Table 2). The sources of Pb pollution could be the prevalent usage of Pb pipes and lead acid batteries manufacturing industries situated in Agra city.

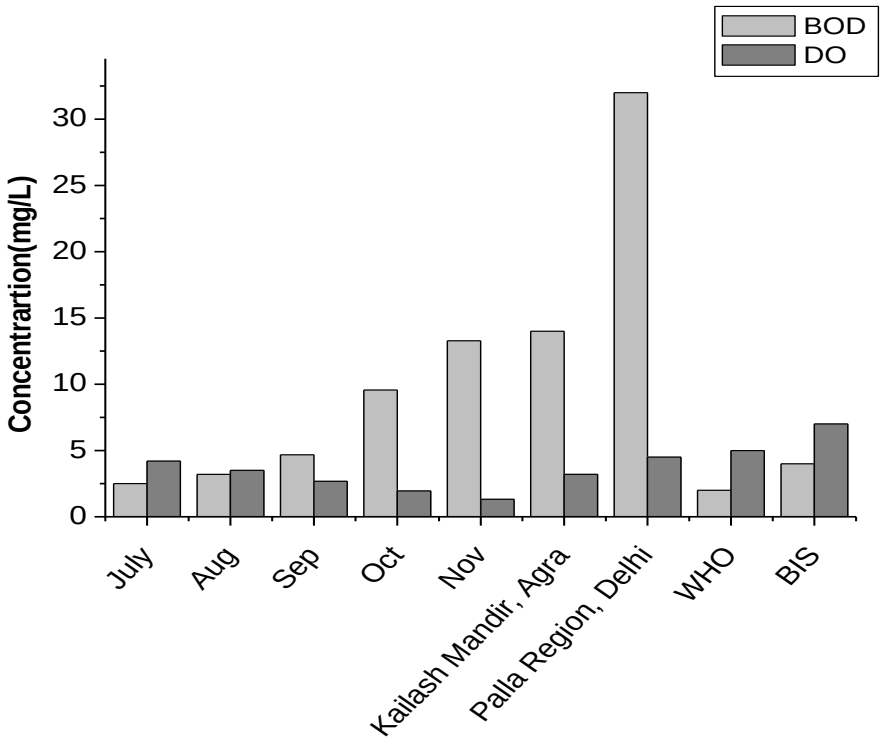

Fig. 9. Trend of BOD and DO level in respective months

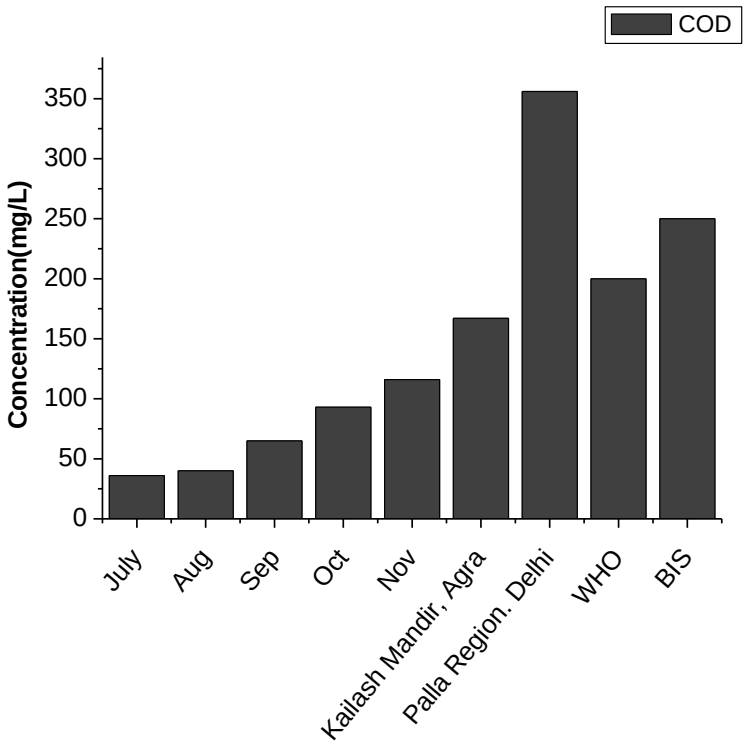

Fig. 10. Trend of COD level in respective months

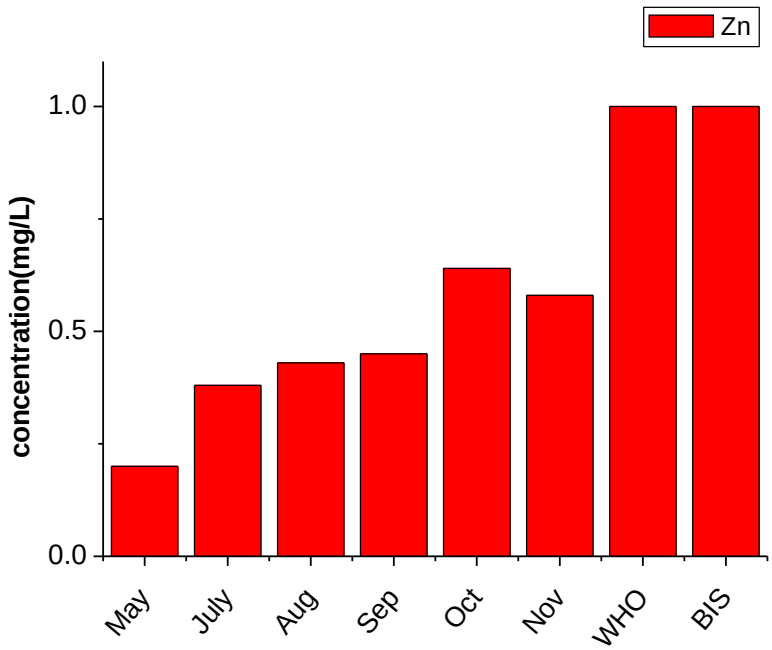

Fig. 11. Trend of Zn level in respective months

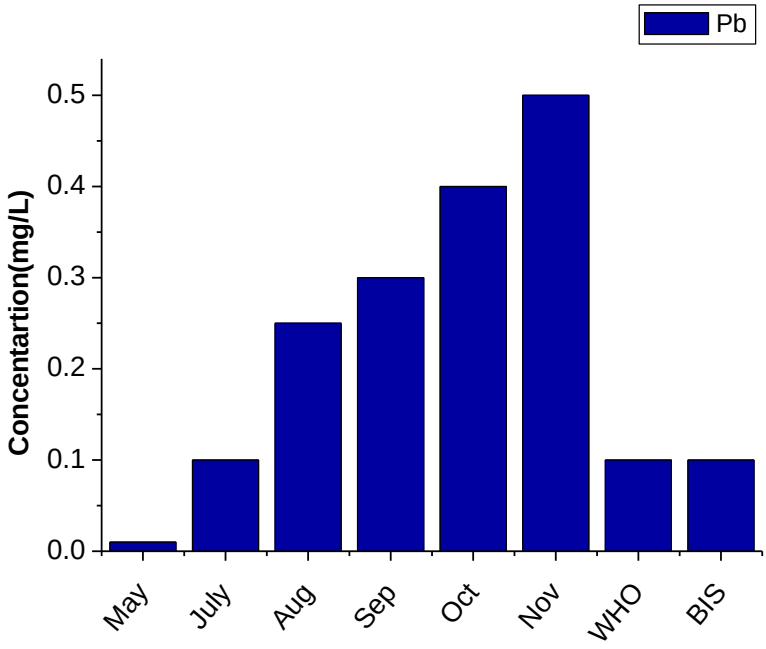

Fig. 12. Trend of Pb level in respective months

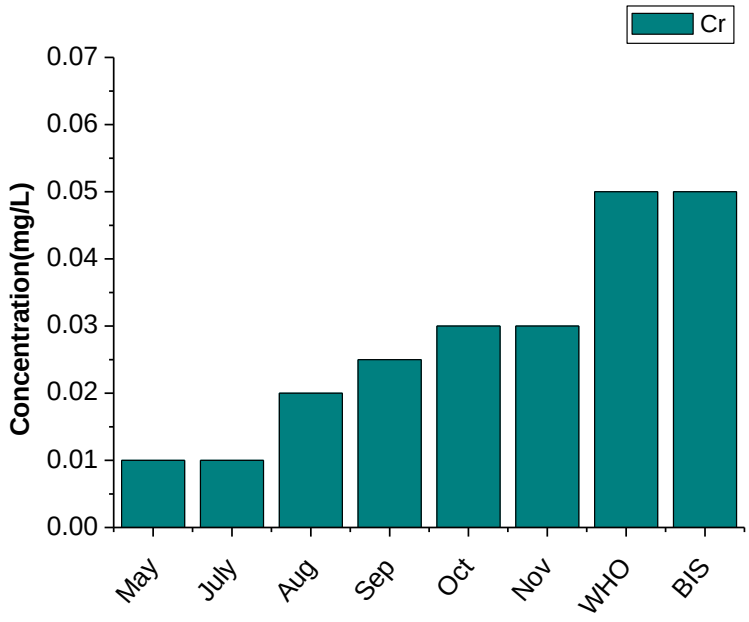

Fig. 13. Trend of Cr level in respective months

The concentration of Chromium was found in the range of 0.01- 0.03 mg/L (Fig. 13, Table 2) and was under the permissible limits of WHO and BIS [13] and shows no potential risk to river water quality.

Table 1. Trend in different water quality parameters in respective months

	pH	EC (µS/cm)	TDS (mg/L)	Hardness (mg/L)	Chloride (mg/L)	Flouride (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)
May	8.1 ±0.6	1300 ±14.3	298±1.2	189±9.6	138.88 ±1.4	2.73 ±0.2			
July	8.02 ±0.7	1500 ±12.5	315±2.7	196±4.2	149.69 ±1.6	3.1 ±0.1	4.2±0.8	2.5±1.4	36±8.6
Aug	7.89 ±0.4	1600 ±13.2	333.25±1.8	208±8.5	180.62 ±1.8	3.23 ±0.3	3.5±0.6	3.2±1.6	40±4.5
Sep	7.76 ±0.2	1800 ±11.6	345.1±2.1	210±9.5	210.76 ±2.1	3.25 ±0.5	2.68±0.5	4.68±1.7	65±2.9
Oct	7.6 ±0.7	1900 ±10.9	387.65±3.2	268±5.8	238.39 ±2.4	3.5 ±0.5	1.95±0.4	9.56±1.4	93±8.7
Nov	7.32 ±0.8	2200 ±8.3	412.38±1.5	289± 3.2	270.36 ±1.9	3.89 ±0.6	1.32±0.9	13.28±1.8	116±9.3
Mean	0.29	318.85	43.66	41.42	51.31	0.39	1.16	4.62	34.37
Standard Deviation	7.78	1716.67	348.56	226.67	198.12	3.28	2.73	6.64	70.00
Yamuna River Sites									
Kailash Mandir, Agra	8.1	1100±11.7	826± 2.5	352±5.4	130±1.8	4.1 ±0.7	3.2±0.7	14±1.3	167±7.8
Palla Region, Delhi	7.5	1711±12.8	1100±7.8	225±3.5	110±2.8	0. 3±0.1	4.5±0.4	32±1.8	356±5.4
Standard Levels									
WHO	**7.5-8.5**	**2000**	**300**	**100**	**250**	**1.2**	**5**	**2**	**200**
BIS	**7.5-8.5**	**3000**	**500**	**300**	**250**	**1.5**	**7**	**4**	**250**

Table 2. Trend in different heavy metals in respective months

Months	Zn (mg/L)	Pb (mg/L)	Cr (mg/L)	Fe (mg/L)
May	0.2± 0.03	0.01±0.01	0.01±0.001	0.4±0.04
July	0.38±0.02	0.1±0.05	0.01±0.001	0.9±0.07
Aug	0.43±0.04	0.25±0.02	0.02±0.001	1.6±0.02
Sep	0.45±0.07	0.3±0.07	0.025±0.007	1.9±0.08
Oct	0.64±0.05	0.4±0.03	0.03±0.005	1.9±0.02
Nov	0.58±0.03	0.5±0.04	0.03±0.002	2.14±0.09
Standard Levels				
WHO	**1.0**	**0.1**	**0.05**	**0.5**
BIS	**1.0**	**0.1**	**0.05**	**0.5**

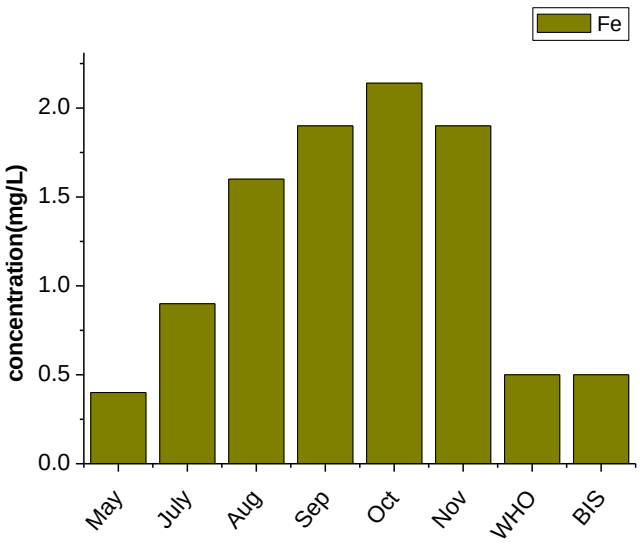

Fig. 14. Trend of Fe level in respective months

In the post- monsoon season, the Fe concentration was found to be very high when compared with WHO and BIS permissible limits for the river [13] (Fig. 14 and Table 2). The high concentration of Fe in sediments were due to the effluent discharge by the number of Iron Foundries situated in Agra region. As the sediment of river Yamuna was highly alkaline, Fe was precipitated as hydroxide under alkaline pH.

Other heavy metals like Ni, Cd, Mn and Cu were found in some water samples in very low concentration which was not significant to cause pollution in River water.

4. CONCLUSIONS

Physico-chemical analysis was conducted on Yamuna River at Poiya Ghat site, Agra to determine its quality and pollution profile over a period of 8 months. The results show the high concentration of some parameters like Total Hardness, TDS, Fluoride content, BOD and COD than the WHO and BIS permissible limits for drinking water. Other parameters like pH, EC, Chloride content, DO were under the permissible limits of WHO and BIS. It was found from the results that all the parameters were high in post-monsoon season as compared to the monsoon and pre- monsoon periods. Heavy metals like Zn, Cr, Ni, Cd, Mn and Cu were very low in concentration while Pb and Fe were high in concentration as compared to the WHO and BIS permissible limits. This shows the high level of pollution in Yamuna River at Poiya Ghat site of Agra. This may possess a health risk to several rural communities as well as urban localities who rely on the river water primarily as their source of domestic water and irrigation. The present study showed an urgent need for a continuous pollution monitoring and treatment programmes of Yamuna river water in India. The control of point sources as well as non-point sources of pollution are vital to clean the river. Government should focus on the different programmes like Yamuna Action Plan (YAP) run by them for the betterment of water quality of Yamuna River.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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