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# Pollution Status of River Hindon from Ghaziabad to Noida with Special Reference to Heavy Metals

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**Abstract:-***The objective of the present study is to investigate the current status of heavy metal pollution in River Hindon, from Ghaziabad to Noida stretch. The concentrations of Nickel, Cadmium, Chromium, Copper, Iron, Manganese, and Zinc in water samples have been studied during January 2013 to December 2014. The overall mean concentration of heavy metals was observed in the following order Fe > Mn> Zn > Ni > Cr > Cu > Cd. Cu and Zinc was found below the standards of WHO and CPCB. The iron was found in maximum concentration and Cd was found in minimum concentration. The average values of all the heavy metals were found as Fe (11.27±3.50), Mn (4.00±1.26), Ni (0.63±0.17), Cr (0.16±0.07), Cu (0.15±0.07), and Cd (0.08±0.07). Based on heavy metal pollution analysis we concluded that our study area as a whole is critically polluted with heavy metals under study due to pollutant load from various anthropogenic activities. One way ANOVA shows statistically significant differences in the levels of all the studied heavy metals between different sites. Games Howell post hoc test shows that there are statistically significant differences ($p<0.05$) in the levels of all the studied heavy metals between Hindon barrage, Indrapuram, Vishnu Nagar and Dadri Road.*

***Keywords:****River Hindon, Heavy metal pollution, Correlation analysis, Industrial effluents.*

## INTRODUCTION

Water is a natural resource. It is primary requirement of man throughout the life. It is naturally recycled through a process called hydrological cycle [12]. We receive fresh water from the rivers but we pollute these water bodies, which causes water pollution. Major cause of water pollution is mismanagement of sewage drains and industrial effluents. The degradation of fresh water system may even jeopardize the other related ecosystems in the biosphere for e.g. marine environment, grass lands, agricultural lands forests. In practical terms, we all are aware of the fact that without water there is no life so rivers are the only life giving support. They are the backbone for sustaining life and its development. It is used for drinking, washing, irrigation and also for energy generation.

The rapid population growths, land development along river basin, urbanization and industrialization have subjected the rivers to increase stress, giving rise to water pollution and environmental deterioration [47]. Most of the rivers in the urban areas of the developing world are the end point of effluents discharged from the industries [38],[22],[23]. In India, sewerage disposal and urban runoff in river catchments areas is the major challenge of river water quality maintenance. Reference [45]concluded that indiscriminate industrialization and urbanization in India have measurably influenced the quality of surface water resources.

India ranks 120th out of 122 countries in terms of water quality. At least 200 million Indian citizens do not have access to safe clean water, a violation of their human right. It is estimated that 90% of India's water resources arecontaminated with untreated industrial, domestic waste, pesticides and fertilizers (Source; FIAN International – 'Investigating some alleged violations of human right to water in India'). India therefore faces a substantial challenge to meet the legal and moral obligations towards the provision of safe water [31].

Heavy metals are serious pollutants due to their toxicity, persistence in natural conditions and ability to be incorporated into food chains [52], [30], [7], [43]. Rapid urbanization and population growth in fast growing cities leading to industrialization poses a major threat of Heavy metal pollution for India's rivers flowing through these cities [50],[19],[04],[02].

River bodies play an important role in assimilating heavy metals form both natural as well as anthropogenic sources. Metals such as Cu, Zn etc are essentially required by different living species in water bodies [08],[11], [13].These heavy metals can enter river systems from either natural or anthropogenic sources [04], [24] ,[24]. The main anthropogenic sources are disposal of untreated and partially treated industrial effluents and sewage containing toxic metals, as well as metal chelates from different industries and indiscriminate use of heavy metal-containing fertilizers and pesticides in agricultural fields [1], [42]. Several researchers have studied heavy metal contamination in various Indian rivers with respect to industrial, municipal, and domestic pollution [49], [05] [48], [39],[16], [17],[18],[36],[33].Various aspects related to water quality of different Rivers in India and its tributaries have been studied by various researchers [26],[27],[46], [09],[10],[11],[12],[13],[14],[29],[41], [44],[16],[35].

 

| | |
|---|---|
| Arsenic (As) | • Pesticides, fungicides, metal smelters |
| Cadmium (Cd) | • Welding, electroplating, pesticides, fertilizer, batteries, nuclear fission plant |
| Chromium (Cr) | • Mining, electroplating, textile, tannery industries |
| Copper (Cu) | • Electroplating, pesticides, mining |
| Lead (Pb) | • Paint, pesticides, batteries, automobile emission, mining, burning of coal |
| Manganese (Mn) | • Welding, fuel addition, ferromanganese production |
| Mercury (Hg) | • Pesticides, batteries, paper industries |
| Nickel (Ni) | • Electroplating, zinc base casting, battery industries |
| Zinc (Zn) | • Refineries, brass manufacture, metal plating, immersion of painted idols |

**Fig. 1- Sources of different heavy metals (Source [37]).**

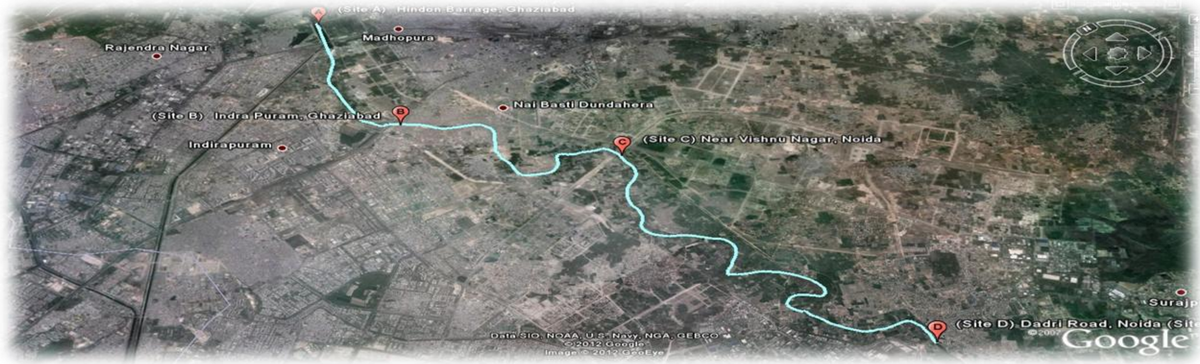


**Fig 2- Showing all the study sites of Hindon River combindly in Google earth map.**

## MATERIALS AND METHODS

### Study area

The Hindon River, historically known as the *Harnandi* River, is a major source of water to the highly populated and predominantly rural population of Western Uttar Pradesh province [31]. Hindon River, a tributary of Yamuna River is a river in India that originates in the Saharanpur District, Uttar Pradesh. The river is entirely rainfed and has a catchment area of 7,083 square kilometers (2,735 sq. mi). The catchment area is a part of the Indo Gangetic Plain, composed of Pleistocene and sub recent alluvium and lies between the latitude 28$^{o}$30' to 30$^{o}$15'N and longitude 77$^{o}$20' to 77$^{o}$50'Eand flows 400 kilometres (250 mi) through six districts, including Muzaffarnagar, Meerut, Baghpat, Ghaziabad and Gautambudh Nagar until its confluence with the Yamuna. The Ganga River in the east and the Yamuna River in the west bounds the Hindon. It is a major source of water to the highly populated and predominantly rural population of western Uttar Pradesh [51]. The study area of the river under present study ranged from its entrance in the Ghaziabad to its confluence with the Yamuna River in Tilwada village, Noida. Total 4 sites were identified and selected for the collection of samples. Fig 2 (Google earth map).

The Following sites were selected for the present study -

A. **Site -1 Hindon Barrage, Ghaziabad**
B. **Site-2 IndraPuram, Ghaziabad**
C. **Site-3 Near Vishnu Nagar, Noida**
D. **Site-4 Dadri Road, Noida**

**Fig 3- Showing sampling site-1(Hindon Barrage, Ghaziabad).**

**Fig 4- Showing sampling site-2(IndraPuram, Ghaziabad).**

**Fig 5- Showing sampling site-3 (Near Vishnu Nagar, Noida).**

**Fig 6- Showing sampling site-4 (Dadri Road, Noida).**

**Selection of Sampling Stations**

Four points were selected and marked along Hindon River to fulfil the purpose of present study. The four stations were with in an approximately 25-26 Kilometres stretch of the river. These sampling stations were selected to assess the pollution load in Hindon River water.

**Collection of Water Samples**

The materials polyvinyl chloride (PVC) bottles were previously decontaminated using the following procedures according [40], before Two days of each sampling date.**(1)** Washing with detergent. **(2)** Rinsing with water to eliminate detergent. **(3)** Rinsing with distilled water. **(4)** Two successive 1 hour shaking treatment with nitric acid. **(5)** Rinsing with distilled water. **(6)** Cleaning with acetone (to dry off water). A previously treated two 2litre plastic (polythene) bottles were used to collect the water samples 1-2 metres away from the shore from about 15-30 Cm below the surface of the water.The samples were collected close to the shore of the Hindon River from all stations between the hours of 7.00am to 10.00am. The samples were then transferred to the laboratory for further analysis. Sampling and analysis was performed with help of APHA[06], Khanna and Bhutiani [25]and Trivedy and Goel[54]. To evaluate the water quality of Hindon River, sampling was done on the monthly basis from January 2013 to December 2014 from four different sampling locations. .

## RESULTS AND DISCUSSION

The heavy metals analysed in Hindon River during the course of study are Manganese (Mn), Zinc (Zn), Cadmium (Cd), Nickel (Ni), Copper (Cu). Chromium (Cr) and Iron (Fe). Monthly average values of heavy metals in 2013 and 2014 including all the sites tabulated in the table no 1 and 2 and the average values of 2013-2014 was tabulated in table no-3 and the standards of WHO and CPCB are tabulated in table no 3

**Iron (Fe)**

The minimum monthly average concentration of iron in 2013 was found 7.34 ppm±1.40 in the month of August and the maximum monthly average concentration in 2013 was found 21.56 ppm±4.33 in the month of May while the average concentrations in 2013 were found as 10.75 ppm±3.91. The minimum monthly average concentration of iron in 2014 was found 7.27 ppm±1.52 in the month of January and the maximum monthly average concentration in 2014 was found 20.05 ppm±3.39 in the month of June while the average concentration in 2014 was found as 11.78 ppm±4.08 while the average concentration during the study period (2013-2014) was foundas 11.27 ppm±3.50. A more or less same trend of iron concentration was observed by[34]. One way ANOVA shows statistically significant differences in iron levels between different sites $F (3, 92) = 3.60$, $P = 0.016$. Games Howell post hoc test shows that there are statistically significant differences ($p<0.05$) in iron levels between Hindon barrage, Indrapuram, Vishnu Nagar, and Dadri Road.

**Manganese (Mn)**

The minimum monthly average concentration of manganese in 2013 was found 2.41 ppm±0.82 in the month of August and the maximum monthly average concentration in 2013 was found 7.51 ppm±2.22 in the month of May while the average concentrations in 2013 were found as 3.97 ppm±1.26. The minimum monthly average concentration of manganese in 2014 was found 2.29 ppm±0.81 in the month of January and the maximum monthly average concentration in 2014 was found 7.24 ppm±1.72 in the month of June while the average concentration in 2014 was found as 4.03 ppm±1.44while the average concentration during the study period (2013-2014) was found as 4.00 ppm±1.26. A more or less same trend of manganese concentration was observed by [03]. One way ANOVA shows statistically significant differences in manganese levels between different sites $F (3, 92) = 9.75$, $P = 0.000$. Games Howell post hoc test shows that there are statistically significant differences ($p<0.05$) in manganese levels between Hindon barrage, Indrapuram, Vishnu Nagar, and Dadri Road.

**Table No 1- Showing monthly average variation in values of Metal Concentration in 2013**

| Month/ Parameters | Fe (ppm) | Mn (ppm) | Cu (ppm) | Cd (ppm) | Ni (ppm) | Cr (ppm) | Zn (ppm) |
|---|---|---|---|---|---|---|---|
| **January** | 10.06 ±1.24 | 3.44 ±0.70 | 0.14 ±0.07 | 0.00 ±0.00 | 0.64 ±0.38 | 0.20 ±0.11 | 1.25 ±0.53 |
| **February** | 8.80 ±1.16 | 3.64 ±0.64 | 0.10 ±0.02 | 0.06 ±0.03 | 0.53 ±0.26 | 0.17 ±0.07 | 1.31 ±040 |
| **March** | 13.33 ±1.78 | 3.77 ±1.26 | 0.18 ±0.02 | 0.25 ±0.17 | 0.64 ±0.34 | 0.28 ±0.12 | 1.75 ±0.88 |
| **April** | 13.00 ±1.25 | 3.89 ±1.02 | 0.17 ±0.04 | 0.07 ±0.04 | 0.61 ±0.28 | 0.25 ±0.10 | 1.61 ±0.62 |
| **May** | 21.56 ±4.33 | 7.51 ±2.22 | 0.38 ±0.27 | 0.23 ±0.15 | 1.12 ±0.73 | 0.28 ±0.12 | 1.82 ±0.56 |
| **June** | 11.53 ±2.04 | 4.79 ±1.42 | 0.02 ±0.01 | 0.21 ±0.11 | 0.72 ±0.37 | 0.05 ±0.03 | 2.67 ±3.74 |
| **July** | 8.78 ±1.11 | 3.25 ±0.90 | 0.02 ±0.01 | 0.11 ±0.06 | 0.69 ±0.27 | 0.07 ±0.04 | 2.49 ±3.58 |
| **August** | 7.34 ±1.40 | 2.41 ±0.82 | 0.12 ±0.07 | 0.00 ±0.00 | 0.56 ±0.17 | 0.00 ±0.00 | 2.02 ±2.94 |
| **September** | 7.84 ±1.80 | 3.61 ±0.54 | 0.08 ±0.04 | 0.00 ±0.00 | 0.38 ±0.19 | 0.00 ±0.00 | 1.15 ±0.35 |
| **October** | 8.13 ±1.42 | 3.17 ±0.59 | 0.09 ±0.02 | 0.00 ±0.00 | 0.27 ±0.12 | 0.08 ±0.04 | 1.11 ±0.26 |
| **November** | 8.99 ±1.64 | 4.28 ±1.36 | 0.11 ±0.05 | 0.05 ±0.02 | 0.44 ±017 | 0.19 ±0.09 | 1.09 ±0.46 |
| **December** | 9.67 ±1.72 | 3.91 ±1.13 | 0.14 ±0.08 | 0.12 ±0.06 | 0.44 ±0.17 | 0.17 ±0.05 | 1.00 ±0.45 |
| **Average±SD** | 10.75 ±3.91 | 3.97 ±1.26 | 0.13 ±0.09 | 0.09 ±0.09 | 0.59 ±0.21 | 0.14 ±0.10 | 1.61 ±0.56 |

**Copper (Cu)**

The minimum monthly average concentration of copper in 2013 was found 0.02 ppm±0.01 in the month of June and July and the maximum monthly average concentration in 2013 was found 0.38 ppm±0.27 in the month of May while the average concentrations in 2013 were found as 0.13 ppm±0.09. The minimum monthly average concentration of copper in 2014 was found 0.09 ppm±0.01 in the month of February and the maximum monthly average concentration in 2014 was found 0.40 ppm±0.25 in the month of June while the average concentration in 2014 was found as 0.17 ppm±0.09 while the average concentration during the study period (2013-2014) was found as 0.15ppm±0.07.Similar results were obtained by [20],[08],[34],[03].One way ANOVA shows statistically significant differences in copper levels between different sites $F (3, 92) = 6.29$, $P = 0.001$. Games Howell post hoc test shows that there are statistically significant differences ($p<0.05$) in copper levels between Hindon barrage, Indrapuram, Vishnu Nagar, and Dadri Road.

**Cadmium (Cd)**

The minimum monthly average concentration of cadmium in 2013 was found below detectable limit and is denoted as 0.000 ppm±0.00 and the maximum monthly average concentration in 2013 was found 0.25 ppm±0.17 in the month of March while the average concentrations were in 2013 found as 0.09 ppm±0.09. The minimum monthly average concentration ofcadmium in 2014 was found 0.02 ppm±0.01 in the month of January the maximum monthly average concentration in 2014 was found 0.23 ppm±0.14 in the month of June while the average concentration in 2014 was found as 0.08 ppm±0.06 while the average concentration during the study period (2013-2014) was found as 0.08 ppm±0.07. A more or less same trend of cadmium concentration was observed by [53], [51],[03],[08].One way ANOVA shows statistically significant differences in cadmium levels between different sites $F (3, 92) = 5.48$, $P = 0.002$. Games Howell post hoc test shows that there are statistically significant differences($p<0.05$) in cadmium levels between Hindon barrage, Indrapuram, Vishnu Nagar, and Dadri Road.

**Nickel (Ni)**

The minimum monthly average concentration of nickel in 2013 was found 0.27 ppm±0.12 in the month of October and the maximum monthly average concentration in 2013 was found 1.12 ppm ±0.73 in the month of May while the average concentrations in 2013 were found as 0.59 ppm±0.21. The minimum monthly average concentration of nickel in 2014 was found 0.29 ppm±0.08 in the month of February and the maximum monthly average concentration in 2014 was found 1.10 ppm ±0.71 in the month of June while the average concentration in 2014 was found as 0.68 ppm±0.21 while the average concentration during the study period (2013-2014) was found as 0.63 ppm±0.17. A more or less same trend of nickel concentration was observed by [08], [15]. One way ANOVA shows statistically significant differences in nickel levels between different sites $F (3, 92) = 31.71$, $P = 0.000$. Games Howell post hoc test shows that there are statistically significant differences ($p<0.05$) in nickel levels between Hindon barrage, Indrapuram, Vishnu Nagar, and Dadri Road.

**Table No 2- Showing average variation in values of Metal Concentration in 2014**

| Month/ Parameters | Fe (ppm) | Mn (ppm) | Cu (ppm) | Cd (ppm) | Ni (ppm) | Cr (ppm) | Zn (ppm) |
|---|---|---|---|---|---|---|---|
| **January** | 7.27 ±1.52 | 2.29 ±0.81 | 0.11 ±0.06 | 0.02 ±0.01 | 0.53 ±0.26 | 0.05 ±0.04 | 0.67 ±0.20 |
| **February** | 8.67 ±1.46 | 3.27 ±0.61 | 0.09 ±0.01 | 0.10 ±0.07 | 0.29 ±0.08 | 0.19 ±0.11 | 1.20 ±0.18 |
| **March** | 8.77 ±1.11 | 3.25 ±0.90 | 0.12 ±0.02 | 0.11 ±0.08 | 0.64 ±0.20 | 0.17 ±0.08 | 1.35 ±0.34 |
| **April** | 10.55 ±1.52 | 3.63 ±0.64 | 0.10 ±0.02 | 0.02 ±0.02 | 0.64 ±0.33 | 0.12 ±0.08 | 1.17 ±0.32 |
| **May** | 19.21 ±4.33 | 6.71 ±2.73 | 0.30 ±0.11 | 0.15 ±0.07 | 0.88 ±0.53 | 0.27 ±0.11 | 1.70 ±0.45 |
| **June** | 20.05 ±3.39 | 7.24 ±1.72 | 0.40 ±0.25 | 0.23 ±0.14 | 1.10 ±0.71 | 0.28 ±0.11 | 1.83 ±0.58 |
| **July** | 10.26 ±1.50 | 3.89 ±0.84 | 0.18 ±0.10 | 0.04 ±0.03 | 0.53 ±0.43 | 0.08 ±0.06 | 1.26 ±0.38 |
| **August** | 9.51 ±1.77 | 3.49 ±1.02 | 0.14 ±0.06 | 0.06 ±0.06 | 0.77 ±0.34 | 0.09 ±0.04 | 0.95 ±0.25 |
| **September** | 11.71 ±1.24 | 3.37 ±0.84 | 0.14 ±0.04 | 0.06 ±0.03 | 0.85 ±0.60 | 0.15 ±0.05 | 1.48 ±0.56 |
| **October** | 13.33 ±1.78 | 3.77 ±1.26 | 0.16 ±0.03 | 0.06 ±0.05 | 0.64 ±0.33 | 0.26 ±0.09 | 1.49 ±0.60 |
| **November** | 13.00 ±1.25 | 3.89 ±1.02 | 0.18 ±0.03 | 0.04 ±0.03 | 0.61 ±0.27 | 0.29 ±0.10 | 1.86 ±0.84 |
| **December** | 9.07 ±1.12 | 3.53 ±1.27 | 0.14 ±0.06 | 0.02 ±0.02 | 0.65 ±0.26 | 0.05 ±0.06 | 0.81 ±0.16 |
| **Average ±SD** | 11.78 ±4.08 | 4.03 ±1.44 | 0.17 ±0.09 | 0.08 ±0.06 | 0.68 ±0.21 | 0.17 ±0.09 | 1.31 ±0.38 |

 

**Chromium (Cr)**
The minimum monthly average concentration of chromium in 2013 was found below detectable limit and is denoted as 0.000 ppm±0.00 and the maximum monthly average concentration in 2013 was found 0.28 ppm±0.12 in the month of March while the average concentrations in 2013 were found as 0.14 ppm±0.10. The minimum monthly average concentration of chromium in 2014 was found 0.05 ppm±0.04 in the month of January and the maximum monthly average concentration in 2014 was found 0.29 ppm±0.10 in the month of November while the average concentration in 2014 was found as 0.17 ppm±0.09 while the average concentration during the study period (2013-2014) was found as 0.16 ppm±0.07. A more or less same trend of chromium concentration was observed by [03],[32], [34].One way ANOVA shows statistically significant differences in chromium levels between different sites $F (3, 92) = 8.27$, $P = 0.000$. Games Howell post hoc test shows that there are statistically significant differences ($p<0.05$) in chromium levels between Hindon barrage, Indrapuram, Vishnu Nagar, and Dadri Road.

**Zinc (Zn)**
The minimum monthly average concentration of zinc in 2013 was found 1.00 ppm±0.45 in the month of December and the maximum monthly average concentration in 2013 was found 2.67 ppm±3.74 in the month of June while the average concentrations in 2013 were found as 1.61 ppm±0.56. The minimum monthly average concentration of zinc in 2014 was found 0.67 ppm±0.20 in the month of January and the maximum monthly average concentration in 2014 was found 1.86 ppm±0.84 in the month of November while the average concentration in 2014 was found as 1.31 ppm±0.38 while the average concentration during the study period (2013-2014) was found as 1.46 ppm±0.38. A more or less same trend of zinc concentration was observed by [03], [34]. One way ANOVA shows statistically significant differences in zinc levels between different sites $F (3, 92) = 8.85$, $P = 0.000$. Games Howell post hoc test shows that there are statistically significant differences ($p<0.05$) in zinc levels between Hindon barrage, Indrapuram, Vishnu Nagar, and Dadri Road.

**Table No 3- Showing average variation in values of Metal Concentration during the study period (2013-2014)**

| Month/ Parameters | Fe (ppm) | Mn (ppm) | Cu (ppm) | Cd (ppm) | Ni (ppm) | Cr (ppm) | Zn (ppm) |
|---|---|---|---|---|---|---|---|
| **January** | 8.66 ±1.97 | 2.86 ±0.81 | 0.12 ±0.02 | 0.01 ±0.02 | 0.58 ±0.08 | 0.12 ±0.12 | 0.96 ±0.41 |
| **February** | 8.73 ±0.10 | 3.45 ±0.26 | 0.10 ±0.00 | 0.08 ±0.03 | 0.41 ±0.17 | 0.18 ±0.02 | 1.26 ±0.08 |
| **March** | 11.05 ±3.22 | 3.51 ±0.37 | 0.15 ±0.05 | 0.18 ±0.09 | 0.64 ±0.00 | 0.22 ±0.08 | 1.55 ±0.28 |
| **April** | 11.77 ±1.73 | 3.76 ±0.18 | 0.13 ±0.05 | 0.05 ±0.03 | 0.62 ±0.02 | 0.19 ±0.09 | 1.39 ±0.31 |
| **May** | 20.38 ±1.66 | 7.11 ±0.56 | 0.34 ±0.06 | 0.19 ±0.09 | 1.00 ±0.17 | 0.27 ±0.01 | 1.76 ±0.09 |
| **June** | 15.79 ±6.02 | 6.02 ±1.73 | 0.21 ±0.27 | 0.22 ±0.01 | 0.91 ±0.27 | 0.17 ±0.16 | 2.25 ±0.60 |
| **July** | 9.52 ±1.05 | 3.57 ±0.46 | 0.10 ±0.12 | 0.08 ±0.05 | 0.61 ±0.11 | 0.07 ±0.01 | 1.88 ±0.87 |
| **August** | 8.42 ±1.53 | 2.95 ±0.77 | 0.13 ±0.02 | 0.03 ±0.04 | 0.66 ±0.14 | 0.04 ±0.06 | 1.48 ±0.76 |
| **September** | 9.77 ±2.74 | 3.49 ±0.17 | 0.11 ±0.04 | 0.03 ±0.04 | 0.61 ±0.33 | 0.07 ±0.10 | 1.31 ±0.23 |
| **October** | 10.73 ±3.68 | 3.47 ±0.42 | 0.12 ±0.05 | 0.03 ±0.04 | 0.45 ±0.26 | 0.17 ±0.13 | 1.30 ±0.27 |
| **November** | 11.00 ±2.83 | 4.09 ±0.28 | 0.15 ±0.05 | 0.05 ±0.00 | 0.53 ±0.11 | 0.24 ±0.24 | 1.47 ±0.55 |
| **December** | 9.37 ±0.43 | 3.72 ±0.27 | 0.14 ±0.01 | 0.07 ±0.07 | 0.55 ±0.14 | 0.11 ±0.08 | 0.90 ±0.14 |
| **Average ±SD** | 11.27 ±3.50 | 4.00 ±1.26 | 0.15 ±0.07 | 0.08 ±0.07 | 0.63 ±0.17 | 0.16 ±0.07 | 1.46 ±0.38 |

The heavy metals analysed in Hindon River during the course of study are Manganese (Mn), Zinc (Zn), Cadmium (Cd), Nickel (Ni), Copper (Cu). Chromium (Cr) and Iron (Fe). Among the heavy metals iron (Fe) was found in higher concentration while cadmium was found in lowest concentration in Hindon River. The overall mean concentration of heavy metals was observed in the following order Fe > Mn> Zn > Ni > Cr > Cu > Cd.The concentration of heavy metals was found higher in the summer season this may be due to low water level, High solar radiation and high evaporation rates of water resulting in accumulation of metal concentration while the minimum concentration in monsoon season may be due to high flow and high water level and dilution effect. All the heavy metal was found in higher concentration because the river is highly polluted in upper stretch of the study region.It can be inferred that higher loadings of river Kali (which is a tributary of Hindon River), which carries municipal waste water and industrial effluents from a variety of industries of Muzaffarnagar region, were observed for all metals in particulate form which may be attributed to sediment transport function. The particulate loading contains highest load of iron and manganese as compared to other metals, which are important carrier for the transport of metal ion. The loading of Kali River is followed by Dhamolanala, which carries municipal waste of Saharanpur city as well as waste effluents from several small scale industrial units [17], [18]. Absorption of cadmium compounds is dependent on the solubility of the compounds [55].

**Table No-4 Showing Heavy metal standards of WHO and CPCB**

| S.N | METALS | WHO STANDARDS | CPCB STANDARDS |
|---|---|---|---|
| 1 | Cd | 0.003 mg/l | 2.0 mg/l |
| 2 | Cr | 0.05 mg/l | 0.1 mg/l |
| 3 | Cu | 2.0 mg/l | 3.0 mg/l |
| 4 | Fe | 0.3 mg/l | 3.0 mg/l |
| 5 | Ni | 0.07 mg/l | 3.0 mg/l |
| 6 | Zn | 5.0 mg/l | 5.0 mg/l |
| 7 | Mn | 0.4 mg/l | 2.0 mg/l |

## CONCLUSION

Result of present analysis reveals that among all the heavy metals studied (Cd, Cr, Ni, Mn, Zn, Fe and Cu) only Cu and Zinc was found below the standards of WHO and CPCB and Nickel was found below the CPCB standards and above the WHO standards while all other metals Cd, Cr, Ni, Mn and Fe exceeded the recommended values and confers the sign of presence of serious metal pollution. If this trend of contamination continues it may make an impact on the quality of water of the Hindon River and in the long run can cause a serious threat for aquatic organisms. Therefore to prevent future adverse impact on the river a restriction must be imposed on the discharge of trace metals and sewages through different sources because the source of these heavy metals in River Hindon is industrial effluent, sewage water and agricultural field's runoff.

## REFERENCE

[1] Abbasi, S.A., Abbasi, N., Soni, R., (1998): Heavy Metals in the Environment. Mittal Publications, New Delhi.
[2] Ahmad, M.K., Islam, S., Rahman, S., Haque, M.R., Islam, M.M., (2010): Heavy metals in water, sediment and some fishes of Buriganga River,Bangladesh. Int. J. Environ. Res. 4 (2):321–332.
[3] Ajmal Mohammad, Raziuddin& Khan AhsanUllah,(1987): Heavy metals in water, sediments, fish and plants of river Hindon, U.P.,India. Hydrobiologia 148:151-157.
[4] Akoto, O., Bruce, T.N., Darko, G., (2008): Heavy metals pollution profiles in streams serving the Owabi reservoir. Afr. J. Environ. Sci. Technol. 2(11):354–359.
[5] Aktar, M.W., Paramasivam, M., Ganguly, M., Purkait, S., Sengupta, D., (2010): Assessment and occurrence of various heavy metals in surface waterof Ganga river around Kolkata: a study for toxicity and ecological impact. Environ. Monit. Assess. 160 (1–4):207–213.
[6] APHA (2005):" Standard methods for the examination of water and waste water.", 21st ed. American Public Health Association, Washington. DC, USA.
[7] Armitage PD, Bowes MJ, Vincent HM. (2007): Long-term changes in macroinvertebrate communities of a heavy metal polluted stream: The rivernent (Cumbria, UK) after 28 years. River Res.23:997–1015.
[8] Asa S.C., Bramha S.N., Mohanty A.K., Bastia T.K., Behera D., and Rath P. (2015): Dynamics and quantification of dissolved metals in highly contaminated river- estuarine System. Indian Journal of Geo-marine Science. 44(9):1310-1322.
[9] Bhutiani R and Khanna D R (2007): Ecological Status of river Suswa: Modelling DO and BOD. Environmental monitoring and assessment. 125: 183-195.
[10] Bhutiani R,Khanna D R,Tyagi B, Tyagi P K and Kulkarni, D B (2015): Assessing environmental contamination of River Ganga using correlation and multivariate analysis. Pollution. 1(3):265-273.
[11] Bhutiani R., Khanna D.R., Shubham and Ahamad Faheem (2016): Physico-chemical analysis of Sewage water treatment plant at Jagjeetpur Haridwar, Uttarakhand.Environ. Cons. Jour. 17(3):133-142.
[12] Bhutiani R., Khanna D.R., Ram Khushi, Ahamad Faheem and Tyagi Varun (2016): Quality assessment of Ganga River at Haridwar with reference to various physico-chemical parameters. Biotech. Int. 9(1):17-24.
[13] Bhutiani R.,Ruhela Mukesh and Ahamad Faheem (2017): Limnological Characterisation of Hindon River at NCR (Uttar Pradesh) India. Environ. Cons. Jour. 18(1&2):219-229.

[14] Bhutiani R., KulkarniDipaliBhasker, KhannaD.R. and GautamAshutosh (2016): Water quality, pollution source apportionment and health risk assessment of heavy metals in groundwater of an industrial area in north India. Water Quality Exposure and Health. 8(1): 3-18.
[15] Bhutiani R., KulkarniDipaliBhasker, Khanna D.R. and GautamAshutosh (2017): Geochemical distribution and environmental risk assessment of heavy metals in groundwater of an industrial area and its surroundings, Haridwar, India. Energy Ecology and Environment. 2(2): 155-167.
[16] GentianaShegani (2016): Seasonal Variation of the Osumi River. Env. and Ecology Res. 4(5):.237-243.DOI: 10.13189/eer.2016.040501
[17] Jain, C.K. and Sharma M.K.(2006): Heavy metal transport in the Hindon river basin, India .Environmental Monitoring and Assessment. 112:255–270. DOI: 10.1007/s10661-006-1706-0
[18] Jain, C.K., Sharma, M.K., (2006): Heavy metal transport in the Hindon river basin, India. Environ. Monit. Assess. 112:255–270.
[19] Karbassi, A.R., Nouri, J., Ayaz, G.O., (2007): Flocculation of trace metals during mixing of Talar river water with Caspian Seawater. Int. J. Environ.Res. 1 (1):66–73.
[20] Karikari A.Y., and Ansa-Asare.O.D. (2006): Physico-Chemical and Microbial Water Quality Assessment of Densu River of Ghana.West African Journal of Applied Ecology. 10(1): http://dx.doi.org/10.4314/wajae.v10i1.45701
[21] Khanna D.R., Bhutiani R,and TrivediManoj(2002). Impact of paper mills effluent on Hindon River Saharanpur (UP).Him. Jr. Env. ZoolVol. 16(1): 125- 128
[22] Khanna D.R., Bhutiani R.(2003a).Limnological status of Satikund pond at Haridwar (U.A) "Indian J. Env. Sc. 7(2): 131-136.
[23] Khanna, D.R,Bhutiani R.(2003b): Limnological characteristics of river Ganga at Haridwar (Uttaranchal), U.P. J. Zool. 23(3): 179-183.
[24] Khanna D.R., Singh Vikas, Bhutiani R.,Chandra, Kumar SatishMattaGaganand Kumar Dheeraj (2007): A Study of biotic and abiotic factors of Song River atDehradun, Uttarakhand. Env. Cons. Jr. 8 (3) : 117-126.
[25] Khanna D.R., and Bhutiani, R. (2008): Laboratory manual for water and wastewater analysis. Daya publishing House, New Delhi.
[26] Khanna D.R., R. Bhutiani and DipaliBhaskarKulkarni (2013): Seasonal variation in ground water quality in and around Integrated Industrial Estate (IIE) Haridwar, India. *Environment Conservation Journ*al 14(3):33-40**.**
[27] Khanna D R, Bhutiani R and Kulkarni D B (2011): A study on pollution status and its impact on water quality of River Ganga at Haridwar. Environ. Cons. Jour. 12(1&2):9-15.
[28] Khanna D R, Bhutiani R and Ruhela M (2013): Fish diversity and their Limnological Status of Ganga river system in foothills of Garhwal Himalaya, Uttaranchal, India. Jour. of Environ. Res. and develop.7 (4): 1374-1380.
[29] Khanna, D.R., Bhutiani R. Tyagi Varun and Ahamad Faheem (2014): Impact of Sugar Mill Effluent on Physico-chemical Properties of Malin River at Najibabad, Bijnore. Indian. J. Sci. Res.Spl. Ed & NSESIR:5-10.
[30] Klavins M, Briede A, Rodinov V, Kokorite I, Parele E, Klavina I. (2000): Heavy metals in rivers of Latvia. Sci. Total Environ. 262:175–183.
[31] Lewis Heather (2007): Hindon River: Gasping for Breath. Janhit Foundation.
[32] LohaniMinaxi B., Singh Amarika, RupainwarD.C.andDhar D.N. (2008): Seasonal variations of heavy metal contamination in river Gomti of Lucknow city region. Environ Monit Assess. 147:253–263 DOI 10.1007/s10661-007-0117-1
[33] Manjunatha, B.R., Balkrishna, K., Shankar, R., Mahalingam, T.R., (2001): Geochemistry and assessment of metal pollution in soils and rivercomponents of a monsoon dominated environment near Karwar, Southwest coast of India. Environ. Geol. 40:1462–1470.
[34] Mishra Saurabh, Kumar Amit, ShuklaPrabhakar. (2015): Study of water quality in Hindon River using pollution index and environmetrics, India. Desalination and Water Treatment:1-10 DOI: 10.1080/19443994.2015.1098570
[35] Neelima, and Jyoti Singh (2013): Seasonal Variation of Water Pollutants in Hindon River. International Journal of Science and Research (IJSR). 5(6):2408-2414. http://dx.doi.org/10.21275/v5i6.NOV164765.
[36] Patil, P.R., Shrivastava, V.S., (2003): Metallic status of river Godavari—a statistical approach. Indian J. Environ. Prot. 23 (6):650–653.
[37] Paul D. (2017): Research on heavy metal pollution of river Ganga: A review. Annals of Agrarian Science 15:278-286.
[38] Phiri O., Mumba P., Moyo B.H.Z., Kadewa W. (2005): Assessment of the impact of industrial effluents on water quality of receiving rivers in urban areas of Malawi. Int. J. Environ. Sci. Technol. 2:237–244.
[39] Prasad, M.B.K., Ramanathan, A.L., Shrivastav, S.K., AnshumaliRajinder, S., (2006): Metal fractionation studies in surfacial and core sediments intheAchankovil river basin in India. Environ. Monit. Assess. 121 (1–3):77–102.
[40] Prendez M., Carrasco M.A. (2003): Elemental composition of surface waters in the Antarctica Peninsula and Interactions with the environment. Enviromental Geochemistry and Health. 25: 346 363.

[41] RizviNida, KatyalDeeksha and Joshi Varun.(2016): Seasonal and spatial variation in the water quality of river Hindon at NCR India. Int. Jr. of Curr. Res.. 8(05):31282-31289.
[42] Reza, R., Singh, G. (2010): Heavy metal contamination and its indexing approach for river water. Int. J. Environ. Sci. 'Technol. 7 (4):785–792.
[43] Sakan SM, Dordevic DS, Manojlovic DD, Predrag PS. (2009): Assessment of heavy metal pollutants accumulation in the Tisza river sediments. J. Environ. Manag .90:3382–3390.
[44] Seth Richa,MohanManindra,Singh Prashant, Singh Rakesh ,DobhalRajendra•,Pal Singh Krishna and Gupta Sanjay (2016): Water quality evaluation of Himalayan Rivers of Kumaunregion,Uttarakhand, India. Appl Water Sci(6):137–147 DOI 10.1007/s13201-014-0213-7
[45] Singh M. and Singh A.K. (2007): Bibliography of environmental studies in natural characteristics and anthropogenic influences on the Ganga River. Environ. Monit. Assess. 129:421–432.
[46] Singh J, Gangwar R K, Khora P and Singh A P (2012): Assessment of physico chemical properties of water River Ramganga at Bareilly, U.P. Jour.Chem. Pharm. Res. 4(9):4231-4234.
[47] Sumok P. (2001): River water quality monitoring: sharing Sarawak experience, in: Proc. 6th Sabah Inter-Agency Tropical Ecosystem (SITE) Research Seminar, Kota Kinabalu, Malaysia, 13–14 September, p. 4.
[48] Sundaray, S.K., (2009): Application of multivariate statistical techniques in hydro-geochemical studies-a case study: Brahmani–Koel River (India).Environ. Monit. Assess. 164 (1–4):297–310.
[49] Sundaray S.K., Nayak, B.B., Kanungo, T.K., Bhatta, D. (2012): Dynamics and quantification of dissolved heavy metals in the Mahanadi Riverestuarine system, India. Environ. Monit. Assess. 184 (2):1157–1179, http://dx.doi.org/10.1007/s10661-011-2030-x.
[50] Sundaray, S.K., Panda, U.C., Nayak, B.B., Bhatta, D., (2006): Multivariate statistical techniques for the evaluation of spatial and temporal variationin water quality of Mahanadi river-estuarine system (India). A case study. Environ. Geochem. Health 28 (4):317–330.
[51] Suthar, SurindraNemaArvind K., ChabukdharaMayuri, Gupta Sanjay K. (2009): Assessment of metals in water and sediments of Hindon River, India:Impact of industrial and urban discharges. Journal of Hazardous Materials. 171:1088–1095.
[52] Szefer P, Geldon J, Ali AA, BawazirA, Sad M. (1997): Distribution and association of trace metals in soft tissue and byssus of mollusc Pernaperna from the Gulf of Aden, Yemen. Environ. Int. 23:53–61.
[53] TaghiniaHejabi, A., Basavarajappa, H.T. and QaidSaeed, A. M**.** (2010): Heavy Metal Pollution in Kabini River Sediments. Int. J. Environ. Res., 4(4):629-636.
[54] Trivedy, P.K. and Goel, P.K. (1986): Chemical and biological methods for water pollution studies. Environment Publication, Karad.
[55] WHO (2008): Guidelines for Drinking-water Quality Third edition incorporating the first and second addenda Volume 1 Recommendations (Electronic source).

 