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A STUDY OF WATER QUALITY ASSESSMENT OF YAMUNA IN DELHI AT DIFFERENT STAGES

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ABSTRACT

Water is among the most essential requisites that nature has provided to sustain life on earth. The total quantity of freshwater on earth can satisfy all needs of human population if it would have been evenly distributed and accessible. Total river flow of the world is about 37000 cubic kilometers, while it is of about 1645 cubic kilometers in India. Rivers are the lifeline of many cities, towns and villages. The water is used in many ways like bathing, drinking, municipal water supply, navigation, irrigation and fishing. Simultaneously, it is used as a course for discharge of industrial effluent, municipal sewage and disposal of solid waste. The river Yamuna originates from Yamunotri glacier and terminates at Allahabad and throughout its stretch it is heavily polluted at Delhi. The water quality assessment of Yamuna in Delhi is a means for determining the condition of Yamuna. Data from monitoring is a tool for sound watershed and community level decision. Many factors can affect the water quality of the river system; the condition of river can fluctuate periodically to look for trends. To assess the water quality of Yamuna four sampling station were selected in the present study namely, Wazirabad entrance of Delhi, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) where the Yamuna River *leaves Delhi. Water quality assessment used here as a header for three group of parameters. Physical (TDS), Chemical (DO, BOD, COD, sulfates, hardness, chlorides etc) and Heavy metals (chromium, zinc, copper). The goal is to provide appropriate picture of current water-quality conditions and water uses. The water quality monitoring is performed with the following objectives: To evaluate water quality trend over a period of time, to assess the fitness of water for drinking purpose and to measure the quality of Yamuna river in Delhi.*

Keywords: pH, TDS, DO, BOD, COD, Turbidity, Sulfate, Alkalinity

Introduction

India is rich in surface water resources. Average annual precipitation is nearly 4000 cubic km and the average flow in the river system is estimated to be 1880 cubic km. Because of concentration of rains in the monsoon months, the utilizable quantum of water is about 690 cubic km. However, conditions vary widely from region to region whereas some are drought affected, others are frequently flooded. With the rapid increase in the population the demand for irrigation, human and industrial consumption of water has increased considerably, thereby causing depletion of water resources. The agriculture production technologies have put a lot of stress on the underground water resources in few areas. The Yamuna River originates from the Yamunotri glacier in the lower Himalayas at an elevation of about 6387 m above mean sea level. The total length of the river from origin to the confluence point at Allahabad is 1376 km. The catchment of the Yamuna river system covers parts of Uttaranchal, Uttar Pradesh, Himachal Pradesh, Haryana, Rajasthan, Delhi and Madhya Pradesh. The river Yamuna is the largest tributary of the river Ganga and flows through series of valleys for about 200 km in lower Himalayas and emerges into Indo-Gangetic plains. In the upper stretch of 200 km, it draws water from several major streams. The combined stream flows through Shivalik range of hills of Himachal Pradesh, Uttar Pradesh and enters into plains at Dak Patthar in U.P as shown in Fig.1 where the river water is regulated through weir and diverted into canal for power generation. From Dak Patthar it flows through Hathnikund/Tajewala in Yamuna Nagar (Haryana), where the river is again diverted into Western Yamuna Canal and Eastern Yamuna Canal for irrigation. During dry season, no water is allowed to flow in the river downstream to Tajewala barrage and the river remains dry in some stretches between Tajewala and Delhi. The River regains water because of ground water accrual; and contributions of feeding canal through Som Nadi upstream of Kalanaur and enters Delhi. The river is again trapped at Wazirabad through a barrage for drinking water supply to Delhi. Generally no water is allowed to flow beyond wazirabad barrage in dry season, as the available water is not adequate to fulfill the demand of water supply of Delhi. The water flows in the downstream of Wazirabad barrage is the untreated or partially treated domestic and industrial wastewater contributed through 22 drains along with the water being transported by Haryana Irrigation department from Western Yamuna Canal to Agra Canal via Najafgarh Drain and the Yamuna. After 22km downstream from Wazirabad barrage there is another Okhla barrage through which the Yamuna water is diverted into Agra canal for irrigation. No water is allowed to flow through barrage during dry season. Whatever water flows in the river beyond Okhla barrage is contributed through domestic and industrial waste water generated from East Delhi, Noida and Sahibabad. The Yamuna after receiving water through other important tributaries joins the river Ganga at Allahabad after traveling via Vrindavan, Mathura, Agra, Etawah, Hamirpur and Pratapgarh. Thus the Yamuna River cannot be designated as continuous river particularly in dry season but is divided into four independent segments.

a) Segment-I (length172km)- Yamunotri to Tajewala barrage
b) Segment-II (length 224km)- Tajewala barrage to Wazirabad barrage
c) Segment-III (length 22km) - Wazirabad barrage to Okhla barrage
d) Segment- IV (958 km)- Okhla barrage to Ganga confluence at Allahabad

Water use of Yamuna River

The uses of Yamuna water can be classified into two categories i.e. Abstractive uses and In-stream uses

1. Abstractive uses: The river is abstracted at different locations for various uses. At Tajewala nearly the entire flow of Yamuna is diverted for irrigation through Western Yamuna Canal and Eastern Yamuna Canal. The annual abstraction at various locations is presented in the following table1.

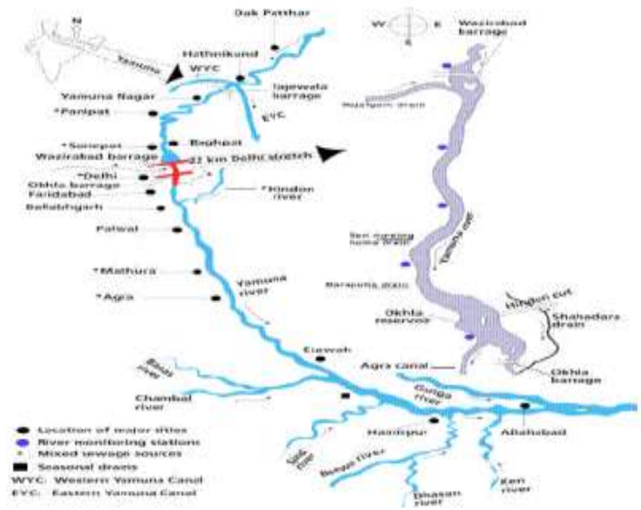

Fig 1.Flow of Yamuna River through various cities

Fig.2.Yamuna at Yamunotri

Fig.3. Yamuna at Delhi

Table.1: Annual Abstraction

Location	Irrigation (million m^3)	Water supply (million m^3)	Others (million m^3)	Total (million m^3)
Tajewala	6000	10	15	6025
Wazirabad	-	275	75	350
Wazirabad-Okhla stretch	1500	-	10	1510
Okhla-Etawah stretch	50	30	10	90
Etawah-Allahabad stretch	100	20	53	173

The various abstractive uses of river water are:

Domestic Water Supply: Delhi, Etawah, Mathura, Agra and Allahabad cities uses the Yamuna water for water supply after conventional treatment. The quantity of water abstracted at these cities is shown in the following fig 4 & 5. Although the actual figures for industrial use is not available, but it is estimated that about 10% of the domestic water supplies is used for industrial purpose.

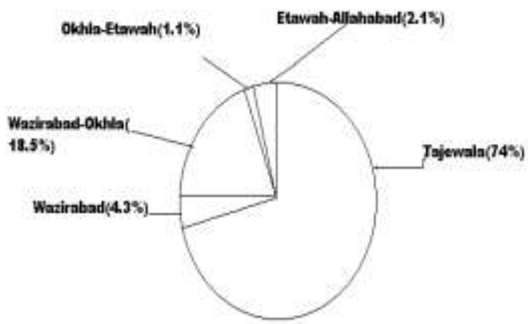

Fig 4. Percentage of water abstracted

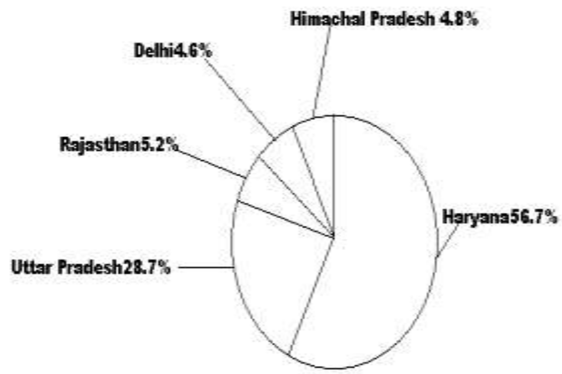

Fig 5. Sharing of Yamuna water among states from Yamuna at various locations

Irrigation: Irrigation is one of the important uses of the Yamuna river water. It is estimated that about 92% of the river water used is only for irrigation. In the Yamuna basin, within the states of Himachal Pradesh, Haryana, Uttar Pradesh, Rajasthan, Madhya Pradesh and Delhi, the net area of about 12.3 million hectares is under irrigation, of which about 49% is irrigated exclusively from surface water.

2. In stream use: The in stream use of River water are

Hydro- power: The total potential for hydropower development in the Yamuna basin has been estimated at about 1331 MW.A potential of about 406 MW has already been created and three schemes with a total power potential of about 463MW are under construction.

Fisheries: Fish farming is not practiced on large scale or organized scale in the river. However, unorganized individual fishermen are utilizing the entire river for fishing.

Navigation: The river system is not presently utilized for inter- state navigation, however short distance navigation is in practice by rowing boat at some places.

Community Bathing and Washing: The entire Yamuna is being used for bathing and washing. On particular religious and cultural occasions when millions of people take holy dip in the river at many places but some on auspicious places it is more intensive.

Cattle bathing and watering: Most of the towns and villages along the river use it for cattle bathing and washing.

According to Khaiwal Ravindra, Ameena Meenakshi, Monika, Rani and Anubha Kaushik [1]. Various physico-chemical characteristics of the River Yamuna flowing in Haryana through Delhi were studied in the summer (April 1998) and winter (Jan.–Feb. 1999). Ecological parameters like dissolved oxygen (DO), pH, nitrate (NO_3^-), sulfate (SO_4^{2--}) and phosphate (PO_4^{3-}) were analyzed and compared with standard permissible limits to assess the best-designated use of the river water for various purposes. The river in Delhi upstream was of better quality whereas the Delhi downstream stretch was polluted as indicated by very low DO and high total dissolved solids (TDS), electric conductivity (EC) and total hardness, Na^+, K^+, Cl^-, F^- and SO_4^{2-}.
Manju Rawat, Mechah Charles Zuriels Moturi and Vaidyanathan Subramanian [2] have worked on Inventory compilation and distribution of heavy metals in wastewater from small-scale industrial areas of Delhi and investigated that Delhi has the highest cluster of small-scale industries (SSI) in India. To study the quantity, quality and distribution of heavy metals in liquid waste from industrial areas, wastewater, suspended materials and bed sediments were collected from industrial areas and from the river Yamuna in Delhi. This study has also focused on the efficiency of production processes in small-scale industries in India. Heavy metals such as Fe, Mn, Cu, Zn, Ni, Cr, Cd, Co and Pb were detected using a GBC 902 atomic absorption spectrometer. The concentration of heavy metals observed was as follows: Fe 2–212, Mn 0.3–39, Cu 0.2–20, Zn 0.2–5, Ni 0.6–6, Cr 0.2–53, Cd 0.08–0.2, Co 0.013–0.55, Pb 0.3–0.7 mg L^{-1} in wastewater; Fe 5842–78 000, Mn 585–10 889, Cu 206–7201, Zn 406–9000, Ni 22–3621, Cr 178–10 533, Co 17–114, Cd 13–141, Pb 67–50 171 mg kg^{-1} in suspended material; and Fe 30 000–84 000, Mn 479–1230, Cu 378–8127, Zn 647–4010, Ni 164–1582, Cr 139–3281, Co 20–

54, Cd 37–65, Pb 228–293 mg kg^{-1} in bed residues. This indicates that SSI could be one of the point sources of metals pollution in the river system.

Sunil Kumar Karn, Hideki Harada [3] has worked on Surface Water Pollution in Three Urban Territories of Nepal, India, and Bangladesh and they found that in South Asian countries such as Nepal, India, and Bangladesh, pollution of rivers is more severe and critical near urban stretches due to huge amounts of pollution load discharged by urban activities. The Bagmati River in the Kathmandu valley, the Yamuna River at Delhi, and peripheral rivers (mainly Buriganga River) of Dhaka suffer from severe pollution these days. The observed dry season average of biochemical oxygen demand (BOD) in all these rivers is in the range of 20-30 mg/l and total coli form are as high as 10^4-10^5 MPN/100 ml. Per capita pollution load discharge of urban areas has been estimated to be about 31, 19, and 25g BOD/capita/day in Bagmati, Yamuna, and the rivers of Dhaka, respectively. Regression analysis reveals pollution loads steadily increasing nearly in step with the trend in urbanization. The dissolved oxygen (DO) level of the Bagmati and Buriganga rivers is declining at an average annual rate of nearly 0.3 mg/l/year. Unplanned urbanization and industrialization occurring in these cities may be largely responsible for this grave situation. Inadequate sewerage, on-site sanitation, and wastewater treatment facilities in one hand, and lack of effective pollution control measures and their strict enforcement on the other are the major causes of rampant discharge of pollutants in the aquatic systems.

Satya P. Mohapatra, Vijay T. Gajbhiye, Narendra P. Agnihotri and Manju Raina [4] have worked on Insecticides pollution of Indian rivers and found that Rivers are the main source of water in India, and are particularly used for agricultural irrigation and drinking water supply. As most of the rivers pass through agricultural fields, they are subject to contamination with the different insecticides used for crop protection. Residues of persistent organochlorines, which are still used in large quantities in India, are found in water from many Indian rivers. In certain rivers, the concentrations of DDT, aldrin and heptachlor are often present in excess of their guideline limits. Although the concentration level of gamma-HCH is well below the guideline limit, the accumulation of the carcinogenic beta isomer is a matter of great concern. A few organophosphorus insecticides have also been detected in river water. Recently, some organochlorine insecticides have been banned from use in India. The use of new, readily biodegradable insecticides and biocides in agriculture and public health programmes offers some optimism

Experimental Programme and Method

In order to assess the water quality of Yamuna in Delhi, four sampling stations were selected

1. At the entrance of Yamuna in Delhi i.e. Wazirabad.
2. At Kashmiri Gate,
3. At Kalindi Kunj (inlet) and
4. At Kalindi Kunj (outlet) i.e. the exit of Yamuna from Delhi.

Grab sampling method was used for the collection of the samples. The sampling was done during the month of February and April. The samples were collected in the plastic bottles ensuring proper preservation. The water samples were subjected to analysis within 24 hours of collection for the physico-chemical parameters like pH, water temperature, dissolved oxygen, biological oxygen demand, chemical oxygen demand, total dissolved solids, chloride ions, turbidity, sulfates, total hardness, calcium and magnesium hardness. The quantitative determination of heavy metals i.e., Cr, Cu, and Zn was also carried out using Atomic Absorption Spectrophotometer. The heavy metals were analyzed after digesting the samples with nitric acid. The analysis has been undertaken using mainly standard methods (APHA, 1998). Analytical values derived from the river samples may vary with depth, velocity of current and the distance of sample taken from the shore which were collected from banks and from the middle of the river by filling the containers held about 0.5 m beneath the surface of water.

Observations and Result

Table: 2 Observation of Physical, Chemical Parameters and Heavy Metals (February)

S.No	Parameters Conc.(mg/L) except if stated	Wazirabad	Kashmiri Gate	Kalindi Kunj (inlet)	Kalindi Kunj(outlet)
1.	Water temperature	18°C	19.5°C	20°C	20°C
2.	pH	7.51	7.12	7.4	7.2
3.	TDS	1010	1370	830	790
4.	DO	6.7	1.0	1.27	1.98

5.	BOD	07	14	11	24
6.	COD	24	68	80	96
7.	Sulfate	82	61	49	98
8.	Turbidity (NTU)	00	72	10	24
9.	Total hardness (as $CaCO_3$)	180	178	124	136
10.	Calcium hardness (as $CaCO_3$)	96	84	68	64
11.	Magnesium hardness (as $CaCO_3$)	84	94	56	72
12.	Chloride	168	292	142.15	124
13.	Alkalinity	40	80	60	68
14.	Cr	-	-	-	0.0001
15.	Copper	0.0031	0.0028	0.0082	0.0024
16.	Zinc	0.0022	0.0219	0.0356	0.0566

Results and discussion:

The present study was carried out to assess the water quality of Yamuna River in parts of Delhi. The sampling was done at Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) was analysed during the month of February and April to compare the various parameters of the river water. The water temperature in Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) are 18°C, 19.5°C, 20°C and 20°C in the month of February and 22, 23.4, 24 and 25.5 in the month of April. Temperature is known to influence the pH, alkalinity and DO concentration in the river water. The value of pH at Wazirabad, Kashmiri gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) are found as 7.51, 7.12, 7.4 and 7.2

Table: 3 Observation of Physical, Chemical Parameters and Heavy Metals (April)

S.No	Parameters Conc.(mg/L) except if stated	Wazirabad	Kashmiri Gate	Kalindi Kunj (inlet)	Kalindi Kunj (outlet)
1.	Water temperature	22°C	23.4°C	24°C	25.5°C
2.	pH	7.93	7.29	7.67	7.55
3.	TDS	1110	1420	890	820
4.	DO	6.12	1.10	1.23	1.68
5.	BOD	8	13	9	18
6.	COD	28.8	64	73.6	80
7.	Sulfate	67.5	47.5	54	81
8.	Turbidity (NTU)	1	76	17	31
9.	Total hardness (as $CaCO_3$)	120	114	82	80
10.	Calcium hardness (as $CaCO_3$)	72	62	46	52
11.	Magnesium hardness (as $CaCO_3$)	48	52	36	28

12.	Chloride	136.12	208.23	102.1	90.1
13.	Alkalinity	40	48	44	36
14.	Cr	-	-	-	-
15.	Copper	0.0027	0.0035	0.0011	0.0011
16.	Zinc	0.0224	0.035	0.0758	0.08

in February and 7.93, 7.29, 7.67 and 7.55 in the month of April. The pH of the river water at Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) & Kalindi Kunj (outlet) in the month of February as compared to the month of April was varied. As compared to winter the pH of river water tended to be higher in the summer season.

The value of TDS at Wazirabad, Kashmiri gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) in the month of February are 1010, 1370, 830 and 790 mg/L and 1110, 1420, 890 and 820 mg/L in the month of April. The drain at Najafgarh caused an increase in the TDS concentration at Kashmiri Gate of the river water.

Fig 6, 7 & 8 shows the variation of pH, TDS and the variation of DO in the month of February and April respectively. DO in the river water at Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) was found to be 6.7, 1, 1.27 and 1.98 mg/L in February and 6.12, 1.1, 1.23 and 1.68 mg/L in the month of April. A lower temperature is known to favor greater dissolution of oxygen in water. DO in good quality streams are usually more than 6 ppm to promote proper growth of fish and other aquatic organisms. Thus the DO level at Wazirabad indicates good quality water. The DO levels fell sharply in Delhi. This depletion of dissolved oxygen in the river water seems to be due to microbial decomposition of the organic matter. High loads of organic pollution reaching the Yamuna from various industries and sewage through drains lead to low oxygen or even anaerobic conditions in the river water downstream of Delhi. Mass fish mortality has been reported in the river at Delhi where DO drops sharply due to a wastewater outfall.

The hardness of the river water as shown in fig- 9 was found out 180,178,124 and 136 mg/L in February and 120, 114, 82 and 80 mg/L in the month of April. Water with a hardness of 50 ppm is considered to be soft. A hardness of 300 ppm is however permissible for domestic use.

whereas it should be 2 to 80 ppm for boiler feeders, 10 to 250 ppm for various food processing industries and 0.05 ppm for laundry and textile industries. For agriculture an upper limit of 150 ppm is usually recommended. The drains at Palla and Najafgarh caused an increase in hardness in Wazirabad and Kashmiri Gate.

The alkalinity of the river water at Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) was found to be 40, 80, 60 and 68 mg/L in the month of February and 40, 48, 44 and 36 mg/L in the month of April as shown in fig 10. The higher values of alkalinity during the winter indicate a greater ability of the river water to support algal growth and other aquatic life in this season.

As shown in fig 11 the Cl^- ion concentration at Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) was found out to be 168,292,142.15 and 124 mg/L in the month of February and 136.12, 208.23, 102.1 and 90.1mg/L in the month of April. Sewage water and industrial effluents are rich in Cl_2 and hence the discharge of these wastes results in high chloride levels in fresh waters.

The SO_4^{2-} concentration in the river at Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) in the month of February was found out to be 82,61,49 and 98 mg/L and 67.5,47.5,54 and 81mg/L in the month of April. Wastewater from tanneries, paper mills and textile mills usually contributes to the SO_4^{2-} in natural water along with some agricultural runoff. The same variation was shown in fig 12.

The COD value at Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) in the month of February was found to be 24, 68, 80 and 96 mg/L and 28.8, 64, 73.6 and 80 mg/L in the month of April.

The BOD values at Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) was found to be 7, 14, 11 and 24mg/L in the month of February and 8,13,9 and 18 mg/L in April.

The high values of BOD may be due to poorly treated wastewater or by high nitrate levels, which can also trigger plant growth which result in higher amounts of organic matter in the river. Fig 13and 14 shows the variation of Cl^- ion & SO_4^{2-} Concentration in the month of February and April

The value of turbidity at Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) in the month of February was found out to be 0, 72, 10, 24 and NTU and 1, 76, 17 and 31 NTU in the month of April. Turbidity in these places may be due to soil run-off and industrial wastewater. The drain at Najafgarh caused an increase in the value of turbidity at Kashmiri Gate as shown in fig 15.

The Chromium concentration at Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) was found out to be 0,0,0.0001 and 0 mg/L in February and 0,0,0and 0 mg/L in April and is less than the permissible limit for drinking which is 0.05 mg/L.

The Cu concentration at Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) was found to be 0.0031,0.0028,0.0082 and 0.0024 mg/L in the month of February and 0.0027,0.0035,0.0011 and 0.0011mg/L in the month of April. The concentration of copper is within the permissible limit and their presences may be due to corrosion of household plumbing system.

The concentration of Zinc at Wazirabad, Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) was found to be 0.0022,0.0219,0.0356 mg/L and 0.0566 mg/L in the month of February and 0.0224,0.035,0.0758 and 0.08 mg/l in the month of April and the concentration of zinc at these places are within the permissible limit. Fig 16 and 17 shows the variation of Cu and Zn in the month of February and April.

CONCLUSIONS

- After comparing the parameters with drinking water quality standards as recommended by Environmental Protection Agency (EPA), World Health Organization (WHO) and BIS it may be concluded that

- The Yamuna River maintains good water quality in upstream stretches i.e. at Wazirabad as compared to downstream stretch i.e. at the remaining three sampling stations.

- At Wazirabad all the parameters are within the permissible limits except TDS, BOD and COD but after necessary treatment it can be used for drinking purpose

- At Kashmiri Gate, Kalindi Kunj (inlet) and Kalindi Kunj (outlet) the water quality degrades to far below the drinking standards and is in fact unfit for any use.

- The concentrations of heavy metals at all the four sampling stations are within the permissible limits.

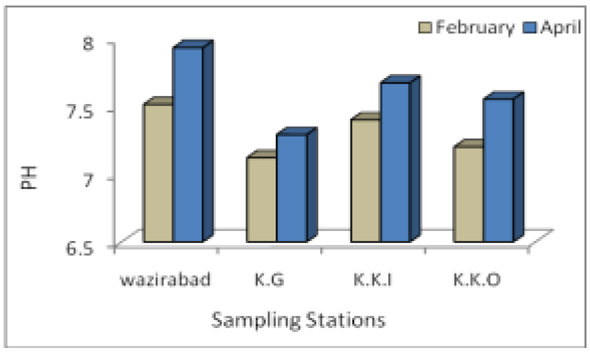

Fig.6. Variation of pH

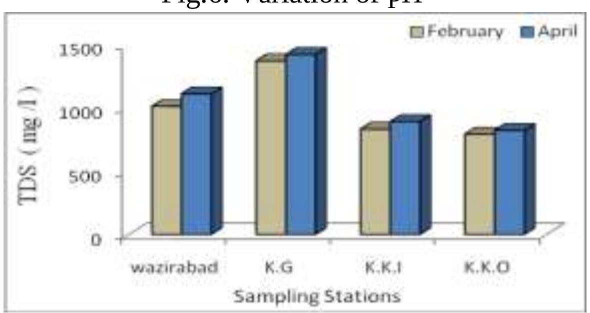

Fig 7. Varaition of TDS

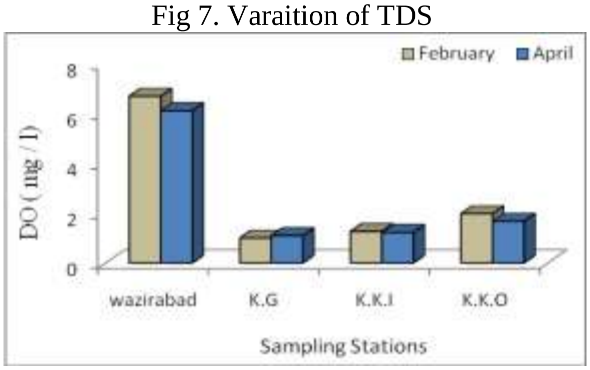

Fig 8. Varaition of DO

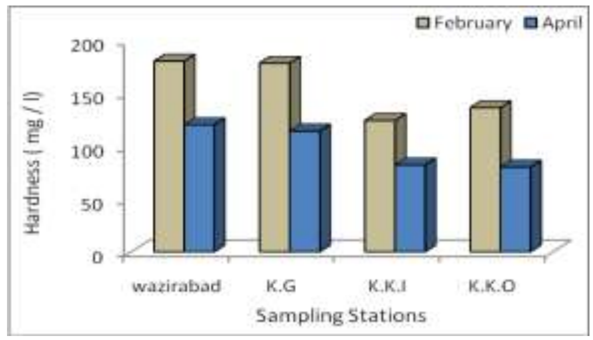

Fig.9 Hardness Variation

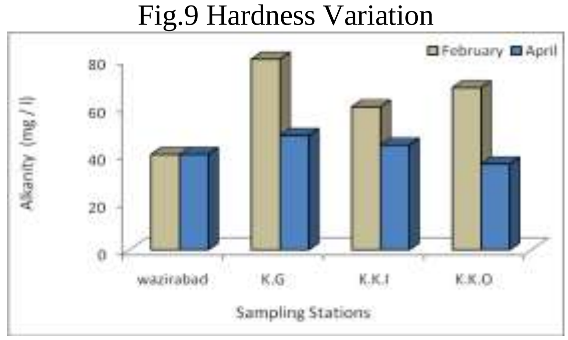

Fig.10 Alkanity Variation

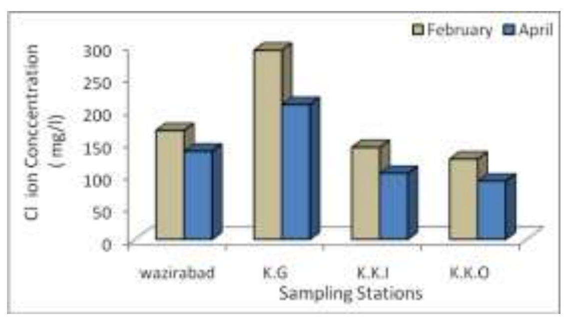

Fig.11 Variation of Cl^- ion

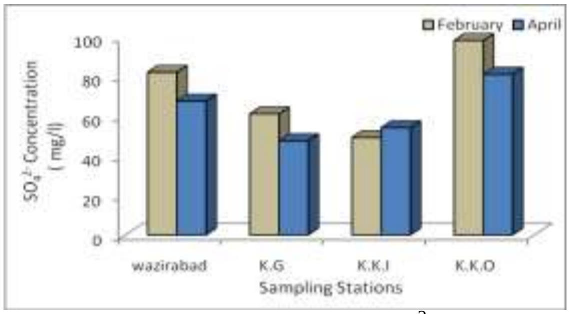

Fig.12 Variation of SO_4^{2-}

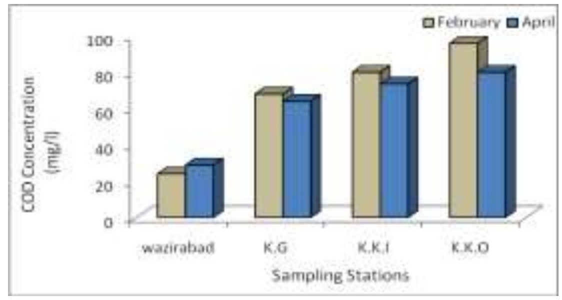

Fig.13 Variation of COD

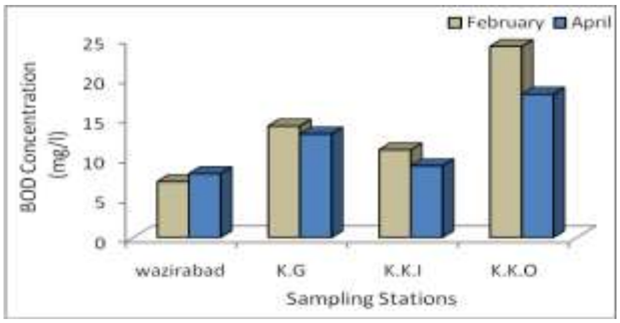

Fig.14 Variation of BOD

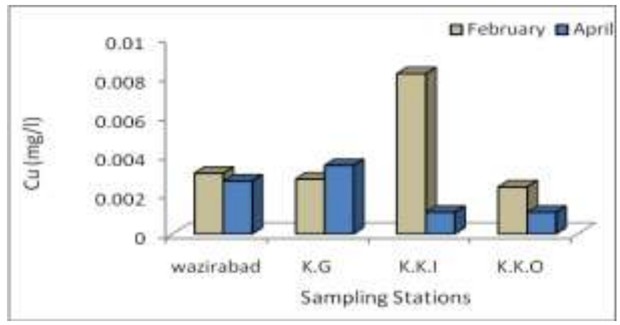

Fig.16 Variation of Cu

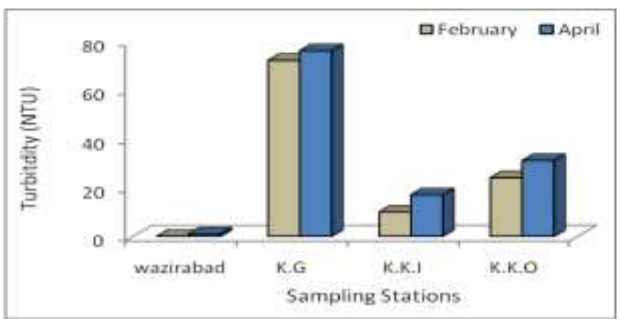

Fig.15 Turbidity Variation

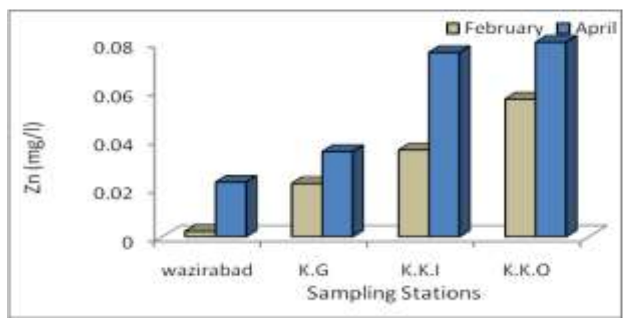

Fig.17 Variation of Zinc

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