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Water quality analysis of River Panv Dhoi in reference to its physico-chemical parameters and heavy metals

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Abstract

This paper deals with the analysis of different water parameters of River Panv Dhoi which flows through Saharanpur district. It is a streamfed river and a tributary of Hindon.The sample collection was usually completed during morning hrs. between 8:00 AM to 10:00 AM. The parameters like Temperature, Turbidity, Conductivity, Total Solids (TS), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), pH, Dissolved Oxygen (DO), Free Carbon dioxide (CO_2), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Alkalinity, Total Hardness, Chloride (Cl^-) and heavy metals like Lead, Zinc, Mercury and copper were analyzed.

Keywords:- *Water, River, Panv Dhoi, Saharanpur, Heavy metals*

Introduction

Water is the most precious commodity of life. It is not only the basic need for sustaining human life but also vital to all the segments of economic development. Water is being adversely affected, qualitatively and quantitatively by all kinds of human activities on land, in air and/or in water.

River Panv Dhoi flows through Saharanpur district. It is a streamfed river and a tributary of Hindon. This river originates near Shanklapuri Shiv Mandir of Panwarka, than it goes to Saharanpur. It is about 15 km in length and then it mixes with river Dhamola (Fig. 1). Metallic scraps, metallic dust, oil, paper and wooden products, besides domestic garbage appear to be the main items of the sewage. Main drain carries away some effluent from the factories and also from the residential colonies. This drain carries domestic sewage, which is poured into river Panv Dhoi. Therefore, it can be well considered that it carries a variety of pollutants of equally different in physico-chemical nature. A lot of work has been done to evaluate the impact of human interferences on different water bodies by Khanna *et al.* (1997), Khanna *et al.* (2000), Khanna and Bhutiani (2003) and Khanna and Chugh (2004) and many more. It is very much essential to monitor the water quality of different water bodies present to asses their suitability for different purposes. Therefore the physico-chemical parameters of river Panv Dhoi were analysed for different seasons during 2002-2003.

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Materials and Method

The samples for different parameters were analysed with the help of the procedure described by Welch (1948), APHA (1980), Mathur (1982), Ross (1983), Trivedi and Goel (1984) and Khanna (1993). The water samples were collected from five different sampliong sites Shanklapuri Shiv Mandir (A), Makhraj Ka Pul (B), Laldas Ka Baada (C), Jogyan Pul (D) and Near Dhamola (E). The sample collection was usually completed during morning hrs. between 8:00 A.M. to 10:00 A.M. The parameters like Temperature, Turbidity, Conductivity, Total Solids (TS), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), pH, Dissolved Oxygen

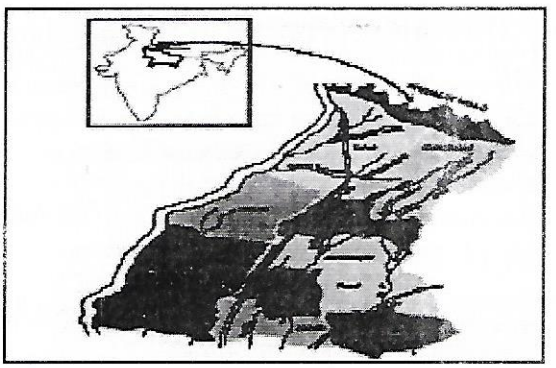

Fig. 1: Map of District Saharanpur showing the situation of Panv Dhoi River

(DO), Free Carbon dioxide (CO_2), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Alkalinity, Total Hardness, Chloride (Cl^-) and heavy metals like Lead, Zinc, Mercury and copper were analyzed.

Results and Discussion

In an aquatic ecosystem the physico-chemical parameters are the main important factors responsible for the biotic healthiness of the system. They show their effect individually and also collectively. The values of different physico-chemical parameters in different seasons were tabulated in the Table 1-10 and are graphically represented in Fig. 2 to 11.

The temperature is one of the most important parameter in an aquatic environment. In the present study, a difference in the fluctuation of water temperature was observed 10.4 ± 1.5 (minimum) in the winter season and 28.0 ± 0.5 (maximum) in monsoon season. Annual average values of temperature varied between 15.6°C ± 4.5 to 25.0°C ± 4.4. Minimum annual average value of temperature was observed at sampling station A and maximum was observed at sampling Station E. The water temperature showed an upward trend from winter season to summer season followed by a downward from monsoon season onwards. A more or less similar trend has been observed in the river Yamuna by Chakrabarty *et al.* (1959) and in the Kallayi (John, 1976). Badola and Singh (1981) also reported similar trend in the river Alaknanda. Same trend of temperature was observed by Khanna *et al.* (2001) in river Ganga at Haridwar.

The present study showed conductivity fluctuation of 65.10 mmhos/cm² ± 2.98 in winter season to 336.78 mmhos/cm² ± 0.58 in monsoon season. Annual average values of conductivity varied between 142.07 mmhos/cm² ± 104.39 to 191.44 mmhos/cm² ± 127.32. Minimum annual average value of conductivity was observed at sampling station E and maximum was observed at Sampling Station A. Identical results were observed by Raina *et al.* (1982) and Mittal and Sengar (1990) from various Indian rivers. Khanna *et al.* (2003) also observed similar trend of conductivity in Ganga river at Bulandshahar.

The water of the river Panv Dhoi becomes start turbid from summer season onward and in rainy season the water was highly turbid. The lowest turbidity was recorded (19.78 JTU ± 1.00) in winter season and highest (1000.00 JTU ± 150.21) noted in monsoon season. Annual average value of turbidity varied between 49.58 JTU ± 40.44 to 908.46 JTU ± 101.05 in which maximum average value observed at sampling station E and minimum at sampling station B. Similar pattern was also reported by Badola and Singh (1981), Dobriyal *et al.* (1983) in the hill streams of the Garhwal Himalaya, Khanna *et al.* (1997) in river Ganga, and Seth *et al.* (2000) in the river Ganga.

In the present investigation it was noted that the total solids were maximum in monsoon season (2400.00 mg/l ± 226.63), which were responsible for the turbidity in the river. The total solids were recorded minimum (68.44 mg/l ± 1.36) in winter season due to gradual sedimentation of the filterable residue. Annual average values of total solids varied between 179.53 mg/l ± 168.53 to 1726.94 mg/l ± 651.22. Minimum average value of total solids was observed at sampling station A and maximum at sampling station E. The highest value of total solids range between 1873 mg/l and 3573 mg/l reported by Kumar and Sharma (2002) in the river Krishni. Total solids cause ecological imbalance in the aquatic ecosystem by mechanical abrasive action. Similar trends were shown by Khanna and Chugh (2004) during study

of water quality of River Ganga at Haridwar. But Khanna and Singh (2000) found that total solids were maximum in summer in the water of Suswa River.

Minimum values of total dissolved solids were obtained during winter season (48.33 mg/l ± 1.57) and maximum values during monsoon season (1100.00 mg/l ± 55.00). Annual average value of total dissolved solids varied between 105.24 mg/l ± 13.10 to 766.66 mg/l ± 351.18, in which minimum average value was obtained from sampling station C and maximum from sampling station E. Same study was also done by Khanna and Chugh (2004) in the river Ganga at Haridwar.

Minimum values of total suspended solids were obtained during winter season (20.11 mg/l ± 0.11) and maximum values during monsoon season (1300.00 mg/l ± 120.04). Annual average value of total suspended solids varied between 57.85 mg/l ± 54.94 to 960.26 mg/l ± 307.78, in which minimum average value was obtained from sampling station A and maximum from sampling station E. Same study was also done by Khanna and Chugh (2004) in the river Ganga at Haridwar.

The Panv Dhoi river at Saharanpur showed high pH value (8.88 ± 0.19) in monsoon season which might be due to increase chemical load in the river. The minimum pH values (7.07 ± 0.26) were observed in winter season. The annual average values of pH varied between 7.32 ± 0.25 to 8.65 ± 0.37. Highest annual average value was recorded at sampling station E and minimum at station A. It was recorded during this study that pH of the river Panv Dhoi is slightly alkaline in nature. Identical results were reported by Sangu and Sharma (1985) in the river Yamuna and Khanna *et al.* (1999) in Ganga river. Khanna *et al.* (2001) in the river Ganga at Hardwar and Khanna *et al.* (2003) in the river Ganga at Bulandshahar have also shown the alkaline nature of river.

The bio-chemical oxygen demand was observed maximum (530 mg/l ± 15.98) in monsoon season and minimum (1.39 mg/l ± 0.17) in winter season. The annual average value of biochemical oxygen demand ranged between 2.26 mg/l ± 0.82 to 468.33 mg/l ± 80.98. The minimum average value was found at sampling station A and maximum at sampling station E. Highest annual average value of bio-chemical oxygen demand at sampling station E may be due to drainage of several small sewage drains into the river and runoff of sludgy, silted sewage during months of rainy season. Khanna & Singh (2000) noticed peak values during summer in Suswa river and Khanna *et al.* (1997) observed peak values in monsoon season in river Ganga.

Chemical Oxygen Demand (COD) represents chemically oxidizable load of organic matter in water. It was noted highest (1240.00 mg/l ± 145.26) in monsoon season and minimum (4.69 mg/l ± 0.18) in winter season. The annual average value of COD ranged between 5.62 mg/l ± 0.69 to 1075.00 mg/l ± 220.17 whereas least average value was found at sampling station B and maximum at sampling station E. Similar trends of COD have shown by Khanna *et al.* (2002, 2003) in the river Ganga and Khanna & Singh (2000) in Suswa River at Raiwala.

Maximum dissolved oxygen was recorded (11.78 mg/l ± 0.25) in the winter season. The minimum value of dissolved oxygen (0.07 mg/l ± 0.01) was observed in monsoon season. The annual average value of dissolved oxygen ranged between 1.68 mg/l ± 1.47 to 9.61 mg/l ± 1.41, whereas the minimum annual average value of DO was observed at sampling station E and maximum was observed at sampling station B. The dissolved oxygen reduced gradually from summer onward due to turbidity which retarded the photosynthetic activity of aquatic flora. The temperature showed an inverse relationship with the DO almost throughout the study. The cause of maximum dissolved oxygen in winter is due to reduced rate of decomposition by decreased microbial activity at low temperature (Strommer and Smock, 1989). Chopra *et al.* (1990), Gopal and Sah (1993) and Sharma (1999) also have got the same result and have opined that low temperature in winter increases the oxygen retaining capacity of water and solubility of O_2 in water. This trend was also observed by Badola and Singh (1981) in the river Alaknanda. Khanna (1993, 2001) and Khanna and Chugh (2004) has also reported the same trends in the river Ganga at Haridwar. Free carbon dioxide was observed maximum (6.24 mg/l ± 0.96) in monsoon season due to

higher turbidity and water temperature, but was recorded minimum (0.07 mg/l ± 0.01) in winter season. Annual average value of free carbon dioxide varied between 2.02 mg/l ± 1.95 to 4.74 mg/l ± 1.56 in which maximum average value obtained from sampling point E and minimum observed at sampling point A. Pahwa and Mehrotra (1966) and Ray *et al.* (1966) have reported that the Ganga river contains maximum free carbon dioxide in rainy season at Allahabad. Khanna *et al.* (1997) and Seth *et al.* (2000) have also reported the same trends in the river Ganga at Haridwar but Khanna and Singh (2000) observed maximum free carbon dioxide during summer in Suswa River at Raiwala, Dehradun.

Alkalinity of water is a measure of weak acid present in it and of the cations balanced against them (Sverdrup *et al.*, 1942). The highest concentration (820.00 mg/l ± 55.27) was observed in summer season and lowest (35.00 mg/l ± 1.38) in winter season. The annual average value of alkalinity varied between 50.02 mg/l ± 15.76 to 781.66 mg/l ± 62.11 in which maximum average value was obtained from sampling station E and minimum from sampling station A. Similar observation was also obtained by Khanna and Chugh (2004), Holden and Green (1960), Tallying and Rzoska (1967) and Abdin (1948).

Maximum values of total hardness were recorded in monsoon season (390.82 mg/l ± 26.71) and minimum was recorded in summer season (83.78 mg/l ± 0.56). The annual average values of total hardness ranged from 95.66 mg/l ± 11.71 to 279.74 mg/l ± 17.27 in which maximum average value is recorded from sampling station E and minimum at sampling station A. Khanna *et al.* (1993, 2003) and Mishra (2003) observed hardness in river Ganga at Hardwar and found more or less similar trends in their study.

The highest and lowest values of chloride were found in monsoon and winter season, 68.32 mg/l ± 4.56 and 1.97 mg/l ± 1.66 respectively. The annual average value of chloride varied between 5.51 mg/l ± 5.29 to 59.67 mg/l ± 3.16 in which maximum average value was recorded from the station E and minimum was at sampling station A. Chlorides are present in sewage, sewage effluents and farm drainage. Significant levels of chloride were shown by many rivers like Yamuna (Sengar *et al.*, 1985); Tungbhadra (Reddy and Venkateswarlu, 1987); Jhelum (Raina *et al.*, 1984) and Kshipra (Mishra and Saxena, 1984). CPCB (2003) reported the value of chloride in between 14 to 51 mg/l during Ganga monitoring from Bithur, Kanpur to Sangam, Allahabad.

The minimum value 0.0638 mg/l ± 0.0072 of lead was found from sampling station A and maximum 5.3975 mg/l ± 0.7123 from sampling station E. The annual average of lead (Pb) ranged between 0.0702 mg/l ± 0.0076 to 4.8452 mg/l ± 0.6109. The minimum value 0.0214 mg/l ± 0.0022 of copper was found from sampling station A and maximum 1.9774 mg/l ± 0.3996 from sampling station E. The annual average value of copper varied between 0.0550 mg/l ± 0.0292 to 1.5945 mg/l ± 0.3729 in which minimum average value of copper was obtained at sampling station A and maximum average value at sampling station E.

Hg is not required even in small amount by any organisms. Virtually all metals, including the essential metal micronutrients, are toxic if exposure levels are sufficient high. The increased circulation of toxic metals in recent times resulted in the unavoidable build up of such toxic substances in the human food chain. The minimum value 3.1224 mg/l ± 0.0467 of zinc was found from sampling station A and maximum 5.0012 mg/l ± 0.1814 from sampling station E. The annual average value of Zinc ranged between 3.1651 mg/l ± 0.0528 to 4.8695 mg/l ± 0.1763 in which minimum average value of Zinc was obtained from sampling station A and maximum was recorded at sampling station E. The annual average value of Mercury varied between 0.0000 ± 0.0000 to 0.0005 mg/l ± 0.0006. The minimum was found as nil at sampling station A, B, C and maximum (0.0009 mg/l ± 0.0007) at sampling station E in. The concentration of these metals at sampling station C, D and E give a highly misleading picture of the degree of metal pollution. Khanna *et al.* (2003) also reported heavy metals in water of Ganga river at Bulandshahar.

Table 1. Seasonal variation in physico-chemical parameters of River Panv Dhoi at sampling station A (2002-2003)

Physico-Chemical Parameters	2002-2003			
	Summer	Monsoon	Winter	Average
Temperature(°C)	18.0 ± 1.3	18.4 ± 1.3	10.4 ± 1.5	15.6 ± 4.5
Conductivity (µmhos/cm²)	138.56 ± 0.40	336.78 ± 0.58	99.00 ± 0.56	191.44 ± 127.32
Turbidity (J.T.U.)	33.22 ± 0.36	120.26 ± 0.37	19.83 ± 0.45	57.78 ± 54.54
Total Solids (mg/L)	96.70 ± 1.35	373.45 ± 1.26	68.44 ± 1.36	179.53 ± 168.83
T.D.S. (mg/L)	64.13 ± 1.41	252.56 ± 1.48	48.33 ± 1.57	121.67 ± 113.62
T.S.S. (mg/L)	32.57 ± 0.04	120.89 ± 0.08	20.11 ± 0.11	57.85 ± 54.94
pH	7.30 ± 0.31	7.57 ± 0.29	7.07 ± 0.26	7.32 ± 0.25
BOD (mg/L)	2.30 ± 0.27	3.08 ± 0.35	1.39 ± 0.17	2.26 ± 0.82
COD (mg/L)	5.02 ± 0.29	7.36 ± 1.09	4.69 ± 0.18	5.69 ± 1.45
DO(mg/L)	9.52 ± 0.34	7.34 ± 1.11	11.78 ± 0.25	9.55 ± 2.18
Free CO_2 (mg/L)	2.02 ± 0.29	3.98 ± 0.19	0.07 ± 0.01	2.02 ± 1.95
Alkalinity (mg/L)	66.67 ± 1.34	48.39 ± 1.22	35.00 ± 1.38	50.02 ± 15.76
Total Hardness (mg/L)	83.78 ± 0.56	107.20 ± 0.71	96.00 ± 0.85	95.66 ± 11.71
Chloride (mg/L)	2.96 ± 1.57	11.58 ± 1.90	1.97 ± 1.66	5.51 ± 5.29

Table 2. Seasonal variation in physico-chemical parameters of River Panv Dhoi at sampling station B (2002-2003)

Physico-Chemical Parameters	2002-2003			
	Summer	Monsoon	Winter	Average
Temperature(°C)	19.8 ± 1.6	20.2 ± 1.2	12.8 ± 0.7	17.6 ± 4.2
Conductivity (µmhos/cm²)	138.15 ± 1.00	336.61 ± 31.12	99.58 ± 7.04	191.44 ± 127.18
Turbidity (J.T.U.)	33.34 ± 1.92	95.62 ± 0.63	19.78 ± 1.00	49.58 ± 40.44
Total Solids (mg/L)	97.75 ± 1.82	377.55 ± 14.51	70.47 ± 1.21	181.92 ± 169.98
T.D.S. (mg/L)	65.17 ± 1.74	254.57 ± 10.79	49.35 ± 4.98	123.03 ± 114.19
T.S.S. (mg/L)	32.58 ± 1.98	122.98 ± 2.03	21.12 ± 1.23	58.88 ± 55.79
pH	7.35 ± 0.90	7.59 ± 0.28	7.09 ± 0.05	7.34 ± 0.25
BOD (mg/L)	2.88 ± 0.62	3.18 ± 0.58	1.57 ± 0.35	2.54 ± 0.86
COD (mg/L)	5.52 ± 0.98	6.36 ± 1.67	4.98 ± 0.79	5.62 ± 0.69
DO(mg/L)	9.65 ± 0.72	8.18 ± 1.02	11.01 ± 0.58	9.61 ± 1.41
Free CO2 (mg/L)	2.08 ± 0.06	4.20 ± 0.12	1.24 ± 0.97	2.56 ± 1.52
Alkalinity (mg/L)	67.67 ± 1.72	49.08 ± 1.21	35.94 ± 0.78	50.89 ± 15.94
Total Hardness (mg/L)	84.01 ± 1.67	108.33 ± 2.61	96.94 ± 0.76	96.44 ± 12.19
Chlorides (mg/L)	3.15 ± 0.92	12.03 ± 0.99	2.37 ± 1.22	5.85 ± 5.37

Table 3. Seasonal variation in physico-chemical parameters of River Panv Dhoi at sampling station C (2002-2003)

Physico-Chemical Parameters	2002-2003			
	Summer	Monsoon	Winter	Average
Temperature(°C)	22.1 ± 0.7	24.2 ± 0.9	14.2 ± 0.6	20.2 ± 5.2
Conductivity (µmhos/cm²)	111.26 ± 6.27	300.24 ± 15.25	85.20 ± 1.79	165.56 ± 117.35
Turbidity (J.T.U.)	250.00 ± 1.34	270.00 ± 9.50	210.00 ± 4.56	243.33 ± 30.55
Total Solids (mg/L)	176.22 ± 13.57	213.32 ± 9.28	170.26 ± 2.67	186.60 ± 23.33
T.D.S. (mg/L)	99.20 ± 5.42	120.28 ± 14.26	96.26 ± 6.21	105.24 ± 13.10
T.S.S. (mg/L)	77.02 ± 4.31	93.04 ± 2.74	74.00 ± 1.28	81.53 ± 10.23
pH	7.48 ± 0.18	7.62 ± 0.20	7.40 ± 0.10	7.50 ± 0.09
BOD (mg/L)	8.44 ± 0.53	11.16 ± 0.29	5.67 ± 0.12	8.42 ± 2.74
COD (mg/L)	26.30 ± 1.26	35.40 ± 1.04	22.65 ± 0.44	28.11 ± 6.56
DO(mg/L)	7.85 ± 0.27	6.56 ± 0.45	8.27 ± 0.89	7.56 ± 0.89
Free CO2 (mg/L)	2.21 ± 0.27	4.12 ± 0.39	1.75 ± 0.34	2.69 ± 1.25
Alkalinity (mg/L)	272.98 ± 9.02	261.55 ± 2.54	249.00 ± 1.04	261.17 ± 11.99
Total Hardness (mg/L)	221.00 ± 1.39	229.32 ± 4.58	215.51 ± 7.21	221.94 ± 6.96
Chloride (mg/L)	32.72 ± 1.85	39.39 ± 1.09	31.26 ± 0.77	34.45 ± 4.33

Table 4. Seasonal variation in physico-chemical parameters of River Panv Dhoi at sampling station D (2002-2003)

Physico-Chemical Parameters	2002-2003			
	Summer	Monsoon	Winter	Average
Temperature(°C)	26.0 ± 0.6	26.9 ± 0.8	17.0 ± 0.7	23.4 ± 5.5
Conductivity (µmhos/cm²)	101.90 ± 1.02	274.78 ± 6.84	70.20 ± 2.22	148.96 ± 110.11
Turbidity (J.T.U.)	550.80 ± 9.95	650.70 ± 17.12	400.24 ± 6.27	533.93 ± 126.06
Total Solids (mg/L)	1536.42 ± 41.23	2315.28 ± 112.21	1030.50 ± 79.62	1627.40 ± 647.20
T.D.S. (mg/L)	755.62 ± 22.32	1015.28 ± 14.21	390.50 ± 7.96	720.46 ± 313.86
T.S.S. (mg/L)	780.80 ± 65.83	1300.00 ± 120.04	640.00 ± 29.32	906.93 ± 347.60
pH	8.80 ± 0.24	8.40 ± 0.15	8.00 ± 0.10	8.42 ± 0.40
BOD (mg/L)	315.00 ± 8.94	325.00 ± 10.08	205.00 ± 14.28	281.66 ± 68.58
COD (mg/L)	750.00 ± 45.21	950.00 ± 40.75	605.00 ± 20.29	768.33 ± 173.22
DO(mg/L)	4.90 ± 0.98	4.00 ± 0.34	5.10 ± 0.45	4.66 ± 0.58
Free CO2 (mg/L)	3.74 ± 1.22	5.38 ± 0.46	2.67 ± 0.94	3.93 ± 1.36
Alkalinity (mg/L)	715.00 ± 47.68	710.25 ± 22.98	708.00 ± 38.12	711.08 ± 3.57
Total Hardness (mg/L)	272.50 ± 6.74	294.00 ± 2.34	261.00 ± 41.08	275.83 ± 16.75
Chloride (mg/L)	58.37 ± 14.78	60.00 ± 8.98	53.12 ± 21.49	57.16 ± 3.59

Table 5. Seasonal variation in physico-chemical parameters of River Panv Dhoi at sampling station E (2002-2003)

Physico-Chemical Parameters	2002-2003			
	Summer	Monsoon	Winter	Average
Temperature (°C)	27.0 ± 0.7	28.0 ± 0.5	20.0 ± 0.6	25.0 ± 4.4
Conductivity (µmhos/cm²)	100.30 ± 4.27	260.90 ± 8.42	65.10 ± 2.88	142.07 ± 104.39
Turbidity (J.T.U.)	925.23 ± 69.32	1000.00 ± 150.21	800.00 ± 22.34	908.46 ± 101.05
Total Solids (mg/L)	1680.82 ± 167.34	2400.00 ± 226.63	1100.00 ± 175.00	1726.94 ± 651.02
T.D.S. (mg/L)	800.00 ± 28.82	1100.00 ± 55.00	400.00 ± 12.05	766.66 ± 351.16
T.S.S. (mg/L)	880.82 ± 14.99	1300.00 ± 87.73	700.00 ± 63.29	960.26 ± 307.78
pH	8.85 ± 0.13	8.68 ± 0.19	8.22 ± 0.10	8.65 ± 0.37
BOD (mg/L)	500.00 ± 35.20	530.00 ± 15.98	375.00 ± 14.71	468.33 ± 80.98
COD (mg/L)	1160.00 ± 0.99	1240.00 ± 145.26	825.00 ± 88.74	1075.00 ± 220.17
DO(mg/L)	2.02 ± 0.24	0.07 ± 0.01	2.96 ± 0.19	1.68 ± 1.47
Free CO2 (mg/L)	4.88 ± 0.64	6.24 ± 0.96	3.12 ± 0.72	4.74 ± 1.56
Alkalinity (mg/L)	820.00 ± 55.27	815.00 ± 45.72	710.00 ± 41.38	781.66 ± 62.11
Total Hardness (mg/L)	276.40 ± 18.45	390.82 ± 26.71	282.00 ± 22.94	279.74 ± 17.27
Chloride (mg/L)	60.54 ± 2.50	68.32 ± 4.56	50.17 ± 6.04	59.67 ± 3.16

Table 6. Seasonal variation in Heavy Metals of river Panv Dhoi at sampling station A (2002-2003)

Heavy Metals	2002-2003			
	Summer	Monsoon	Winter	Average
Lead (Pb) (mg/L)	0.0680 ± 0.0072	0.0798 ± 0.0070	0.0638 ± 0.0072	0.0702 ± 0.0076
Copper (Cu) (mg/L)	0.0696 ± 0.0067	0.0740 ± 0.0069	0.0214 ± 0.0022	0.0550 ± 0.0292
Zinc (Zn) (mg/L)	3.1224 ± 0.0467	3.1486 ± 0.0513	3.2242 ± 0.0538	3.1851 ± 0.0528
Mercury (Hg) (mg/L)	0.0000 ± 0.0000	0.0000 ± 0.0000	0.0000 ± 0.0000	0.0000 ± 0.0000

Table 7. Seasonal variation in Heavy Metals of river Panv Dhoi at sampling station B (2002-2003)

Heavy Metals	2002-2003			
	Summer	Monsoon	Winter	Avearage
Lead (Pb) (mg/L)	0.0697 ± 0.0077	0.0790 ± 0.0072	0.0647 ± 0.0065	0.0711 ± 0.0073
Copper (Cu) (mg/L)	0.0739 ± 0.0284	0.0814 ± 0.0301	0.0324 ± 0.0324	0.0626 ± 0.0269
Zinc (Zn) (mg/L)	3.2258 ± 0.0265	3.2260 ± 0.0251	3.1810 ± 0.0231	3.2109 ± 0.0259
Mercury (Hg) (mg/L)	0.0000 ± 0.0000	0.0000 ± 0.0000	0.0000 ± 0.0000	0.0000 ± 0.0000

Table 8. Seasonal variation in Heavy Metals of river Panv Dhoi at sampling station C (2002-2003)

Heavy Metals	2002-2003			
	Summer	Monsoon	Winter	Average
Lead (Pb) (mg/L)	1.645 ± 0.3830	1.982 ± 0.4136	1.224 ± 0.2184	1.6170 ± 0.3797
Copper (Cu) (mg/L)	0.0872 ± 0.0181	0.0985 ± 0.0186	0.0649 ± 0.0161	0.0835 ± 0.017
Zinc (Zn) (mg/L)	3.6527 ± 0.2056	3.8928 ± 0.2132	3.4812 ± 0.2001	3.6755 ± 0.2067
Mercury (Hg) (mg/L)	0.0000 ± 0.0000	0.0000 ± 0.0000	0.0000 ± 0.0000	0.0000 ± 0.0000

Table 9. Seasonal variation in Heavy Metals of river Panv Dhoi at sampling station D (2002-2003)

Heavy Metals	2002-2003			
	Summer	Monsoon	Winter	Average
Lead (Pb) (mg/L)	3.2755 ± 0.0.796	3.3972 ± 0.08120	3.2527 ± 0.0612	3.3084 ± 0.0776
Copper (Cu) (mg/L)	0.8475 ± 0.1761	0.9976 ± 0.1810	0.6474 ± 0.161	0.8308 ± 0.1756
Zinc (Zn) (mg/L)	4.2186 ± 0.01230	4.3270 ± 0.0112	4.1874 ± 0.0149	4.2443 ± 0.0732
Mercury (Hg) (mg/L)	0.0001 ± 0.00000	0.0002 ± 0.00000	0.0000 ± 0.0000	0.0001 ± 0.0000

Table 10. Seasonal variation in Heavy Metals of river Panv Dhoi at sampling station E (2002-2003)

Heavy Metals	2002-2003			
	Summer	Monsoon	Winter	Average
Lead (Pb) (mg/L)	4.9492 ± 0.6260	5.3975 ± 0.7123	4.1889 ± 0.5600	4.8452 ± 0.6109
Copper (Cu) (mg/L)	1.5737 ± 0.3631	1.9774 ± 0.3996	1.2324 ± 0.2998	1.5945 ± 0.3729
Zinc (Zn) (mg/L)	4.9384 ± 0.1796	5.0012 ± 0.1814	4.6692 ± 0.1616	4.8695 ± 0.1763
Mercury (Hg) (mg/L)	0.0002 ± 0.0004	0.0009 ± 0.0007	0.0004 ± 0.0005	0.0005 ± 0.0006

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Fig. 2. Seasonal variation in physico-chemical parameters of River Panv Dhoi at sampling station A (2002-2003)

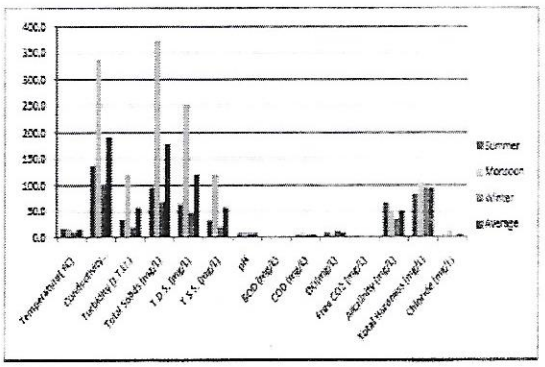

Fig. 3. Seasonal variation in physico-chemical parameters of River Panv Dhoi at sampling station B (2002-2003)

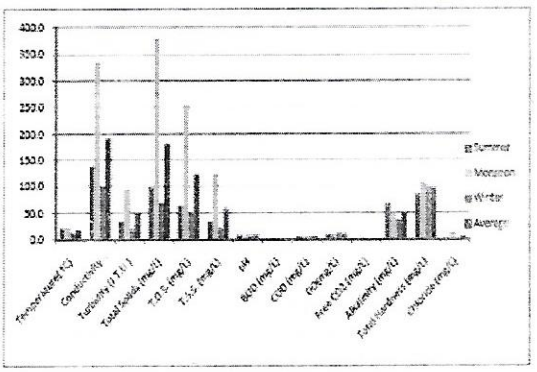

Fig. 4. Seasonal variation in physico-chemical parameters of River Panv Dhoi at sampling station C (2002-2003)

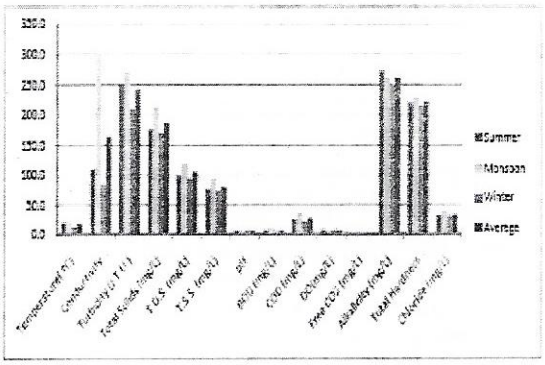

Fig. 5. Seasonal variation in physico-chemical parameters of River Panv Dhoi at sampling station D (2002-2003)

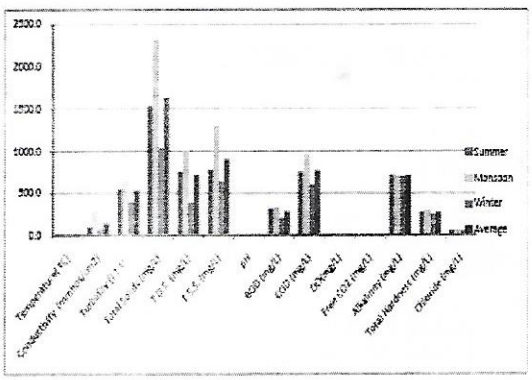

Fig. 6. Seasonal variation in physico-chemical parameters of River Panv Dhoi at sampling station E (2002-2003)

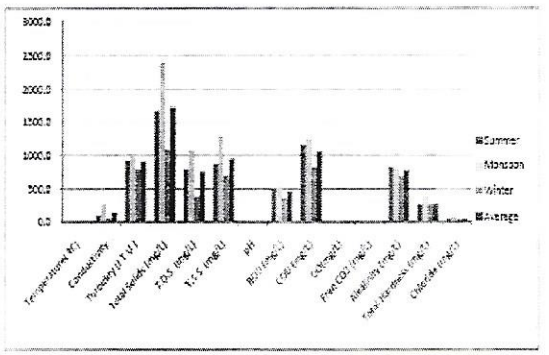

Fig. 7. Seasonal variation in Heavy Metals of river Panv Dhoi at sampling station A (2002-2003)

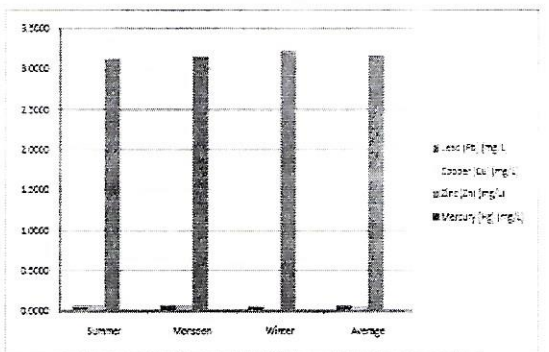

Fig. 8. Seasonal variation in Heavy Metals of river Panv Dhoi at sampling station B (2002-2003)

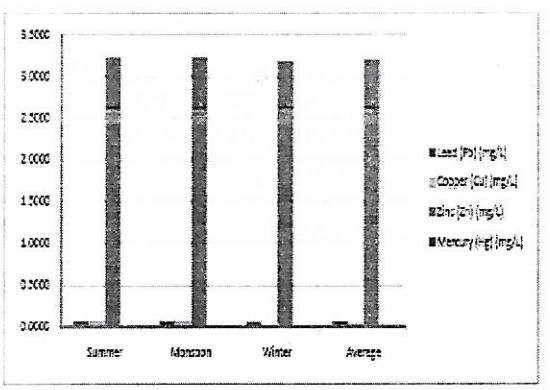

Fig. 9. Seasonal variation in Heavy Metals of river Panv Dhoi at sampling station C (2002-2003)

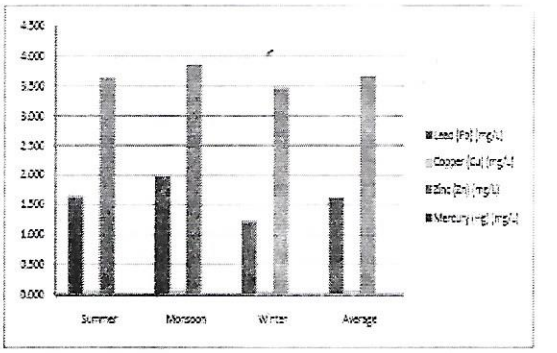

Fig. 10. Seasonal variation in Heavy Metals of river Panv Dhoi at sampling station D (2002-2003)

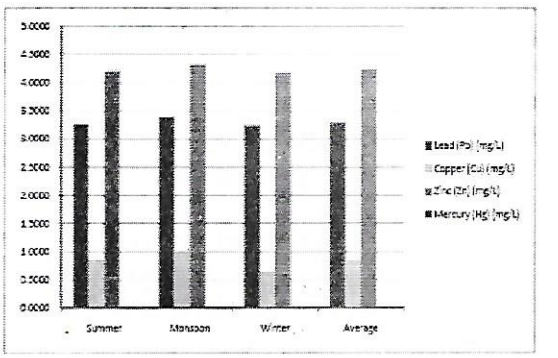

Fig. 11. Seasonal variation in Heavy Metals of river Panv Dhoi at sampling station E (2002-2003)