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PHYSICO-CHEMICAL ANALYSIS OF PONDS AND RIVER WATER IN DARBHANGA

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Abstract

Darbhanga (26.1542° N, 85.8918° E) is an important city of North Bihar, India. Water qualities of five experimental sites, three of the river Bagmati and two of the ponds at Darbhanga were studied during two consecutive years on thirteen physico-chemical parameters viz., pH, Temperature, Transparency, Conductivity, Total Dissolved Solids, Dissolved Oxygen, Free Carbon di-oxide, Carbonate Alkalinity, Bicarbonate Alkalinity, Total Hardness, Calcium, Chloride and Silicate. Observed values of pond water on pH, Temperature, Carbonate Alkalinity, Chloride and Silicate were found comparatively higher than that of river water, whereas Transparency, Dissolved Oxygen, Bicarbonate Alkalinity, Total Hardness, Calcium of pond water were found lower than the river water.

Keyword: *Darbhanga, Bagmati, pond, physico-chemical, limnology*

INTRODUCTION

In the present study,five different experimental sites, three of the river Bagmati and two of ponds were selected for the study of diatons and the physico-chemical quality of water. The three sites of the river Bagmati are: 1. Near Mabbi as site -1, under the bridge at Shobhankarpur as site-2, and near Ekmi as site -3. and two ponds are: 1. Ganga Sagar pond at Marwari College, Darbhanga and 2. Harahi pond at Railway Station,Darbhanga were selected for study. Water samples were collected from these five sampling sites in the season of summer, rain and winter from August 2018 to December 2019.. Thirteen physico-chemical parameters were studied, these are : pH, Temperature, Transparency, Conductivity, Total Dissolved Solids, Dissolved Oxygen, Free Carbon di-oxide, Carbonate Alkalinity, Bicarbonate Alkalinity, Total Hardness, Calcium, Chloride and Silicate.

MATERIALS AND METHODS

Standard methods as described by APHA (1995) were followed for the determination of various physico-chemical parameters.

OBSERVATION

pH: Table 1a shows that pH of the river water ranged from 7.10 to 8.50 during the observation period of two years. The maximum value of pH 8.50 was observed in the summer of 2015 at site-II and minimum 7.10 in the rain of 2015 at site-I. Table Ib shows yearly mean of the pH of the river water 7.82 in 2015 and 7.88 in 2016. The seasonal mean of pH was maximum 8.02 in the summer and minimum 7.65 in the winter. As shown in the Table 1a, pH of pond water ranged from 7.30 to 8.40 and 7.35 to 8.40 in pond-I and pond-II respectively.

Table 1a : Observed pH of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	7.40	8.30	8.00	8.10	7.10
	2019	7.60	8.00	8.10	8.30	8.50
Rain	2018	7.00	8.20	8.10	8.10	8.25
	2019	7.40	8.30	8.40	8.00	7.45
Winter	2018	8.00	7.00	7.10	7.30	7.80
	2019	7.40	7.40	7.40	7.20	7.30

Table 1b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	7.68 ± 0.54	7.78 ± 0.54	7.90 ± 0.33	7.90 ± 0.35	7.38 ± 0.35
Pond (both ponds)	7.78 ± 0.47	7.79 ± 0.55	8.00 ± 0.62	7.95 ± 0.35	7.40 ± 0.27

Temperature(◦C) : Table 2a shows that Temperature of the river water ranged from 19.0◦C to 30.0◦C during the observation period of two years. The maximum value of temperature 30.60◦C was observed in the summer of 2019 at site -2 and minimum 19.0 ◦C in the winter of 2018 at site-1. Table 2b shows yearly mean of the temperature of the river water 26.36◦C in 2018 and 26.07◦C in 2019.The seasonal mean of temperature was maximum 30.16 ◦C in the summer and minimum 19.16◦C in the winter. As shown in the table 2a, temperature of pond water ranged from 18.20 ◦C to 35.50 ◦C and 18.10 ◦C to 34.80◦C in pond 1 and pond 2 respectively. It is also evident from the table 2b that yearly mean of the temperature of the pond water was 28.25 ◦C in 2018 and 27.71 ◦C in 2019.The seasonal mean of temperature was maximum 34.08 ◦C during summer and minimum 18.42 ◦C during winter.

Transparency (cm) : Table 3a shows that transparency of the river water ranged from 5cm to 6 40cm during the observation period of two years. The maximum value of transparency 63.40cm was observed in the winter of 2018 at site-2 and minimum 6.5cm in the rain of 2018 at site-3. Table 3b shows yearly mean of the transparency of the river water 28.91cm in 2018 and 27.21cm in 2019.The seasonal mean of transparency was maximum 52.91cm in the winter and minimum 10.33cm in the rain. As shown in the table 3a,transparency of pond water ranged from 17.3cm to 13.3cm and 17.7cm to 29.0cm in pond 1 and pond 2 respectively. It is also evident from the table 3.3b, that yearly mean of the transparency of the pond water was 23.53cm in 2018 and 22.88cm in 2019. The seasonal mean of transparency was maximum 27.52cm during winter and minimum 19.27cm during rain.

Table 2a : Observed Temperature (C) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	30.00	30.40	30.60	35.30	34.80
	2019	29.40	30.60	30.00	35.00	34.10
Rain	2018	29.40	30.00	29.50	30.50	31.50
	2019	28.10	29.00	30.00	30.40	30.50
Winter	2018	19.00	19.40	19.00	18.40	19.00
	2019	19.40	19.10	19.10	18.20	18.10

Table 2b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	26.37 ± 5.44	26.08 ± 5.44	30.17 ± 0.46	29.33 ± 0.19	19.17 ± 0.19
Pond (both ponds)	28.25 ± 7.63	27.72 ± 7.64	34.80 ± 0.51	30.73 ± 0.52	18.43 ± 0.40

Table 3a : Observed Transparency (cm) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	20.50	18.50	21.20	24.00	24.30
	2019	23.70	23.30	18.40	21.00	22.00
Rain	2018	8.50	13.20	6.50	20.60	21.50
	2019	14.00	10.10	9.70	17.30	17.70
Winter	2018	53.30	63.40	55.10	28.40	22.40
	2019	44.50	55.70	45.50	30.30	29.00

Table 3b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	28.91 ± 22.01	27.21 ± 22.01	20.93 ± 2.27	10.33 ± 7.05	52.92 ± 7.05
Pond (both ponds)	23.53 ± 2.78	22.88 ± 5.56	22.83 ± 1.59	19.28 ± 2.09	27.53 ± 3.51

Conductivity(µmhos) : Table 4a shows that conductivity of the river water ranged from 294.0 µmhos to 672.0 µmhos during the observation period of two years. The maximum value of conductivity 672.0 µmhos was observed in the winter of 2019 at site -2 and minimum 294.0 µmhos in the summer of 2018 at site-1 and site-3. Table 4b shows yearly mean of the conductivity of the river water 385.77 µmhos in 2018 and 466.44 µmhos in 2019.The seasonal mean of conductivity was maximum 545.66 µmhos in the winter and minimum 320.00 µmhos in the summer. As shown in the table 4a, conductivity of pond water ranged from230.35 µmhos to 635.0 µmhos and 235.0 µmhos to 610.0 µmhos in pond 1 and pond 2 respectively. It is also evident from the table 4b,that yearly mean of the conductivity of the pond water was 426.66 µmhos in 2018 and 432.55 µmhos in 2019.The seasonal mean of conductivity was maximum 616.0 µmhos during rain and minimum 238.83 µmhos during winter.

Total Dissolved Solid (TDS) (ppm): Table 5a shows that TDS of the river water ranged from 191.50 ppm to 435.45ppm during the observation period of two years. The maximum value of TDS 435.45ppm was observed in the winter of 2019 at site-2 and minimum 191.50ppm in the summer of 2018 at site -1. Table 5b shows yearly mean of the TDS of the river water 250.51ppm in 2018 and 300.28 ppm in 2019.The seasonal mean of TDS was maximum 353.84 ppm in the winter and minimum 208.97 ppm in the summer. As shown in the table 3.5a, TDs of pond water ranged from 145.43ppm to 410.75ppm and 154.4ppm to 394.5ppm in pond 1 and pond 2 respectively. It is also evident from the table 3.5b , that yearly mean of the TDS of the pond water was 273.28ppm in 2018 and 280.67ppm in 2019.The seasonal mean of TDS was maximum 398.49 ppm during rain and minimum 149.83ppm during winter.

Table 4a : Observed Conductivity (µmhas) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	294.00	322.00	295.00	410.00	415.00
	2019	335.00	344.00	330.00	470.00	440.00
Rain	2018	345.00	376.00	390.00	635.00	610.00
	2019	396.00	435.00	334.00	610.00	610.00
Winter	2018	430.00	510.00	510.00	245.00	245.00
	2019	634.00	672.00	518.00	230.00	235.00

Table 4b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	385.78 ± 83.16	444.22 ± 83.16	320.00 ± 21.00	379.33 ± 89.95	545.67 ± 89.95
Pond (both ponds)	426.67 ± 169.37	432.50 ± 169.99	433.75 ± 27.50	616.25 ± 12.50	238.75 ± 7.50

Table 5a : Observed Total Dissolved Solids (ppn) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	191.50	210.30	191.50	264.25	270.70
	2019	217.65	225.25	217.65	310.50	285.00
Rain	2018	220.55	245.75	25 50	410.75	394.50
	2019	240.05	280.10	340.80	394.24	394.50
Winter	2018	280.50	330.50	330.50	140.25	159.25
	2019	410.70	435.45	335.40	145.43	154.40

Table 3.5b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	250.51 ± 53.86	300.34 ± 53.86	208.98 ± 14.34	263.46 ± 57.80	353.84 ± 57.80
Pond (both ponds)	273.28 ± 113.47	280.68 ± 110.45	282.61 ± 20.51	398.50 ± 8.17	149.83 ± 8.58

Dissolved Oxygen (ppm) : Table 6a shows that dissolved oxygen of the river water ranged from 5.70ppm to 10.0ppm during the observation period of two years. The maximum value of dissolved oxygen 10.0ppm was observed in the winter of 2018 at site-2 and minimum dissolved oxygen 5.70ppm in the rain of 2018 at site-2. Table 6b shows yearly mean of the dissolved oxygen of the river water 7.19ppm in 2018 and 8.21ppm in 2019.The seasonal mean of dissolved oxygen was maximum 9.11ppm in the winter and minimum 6.31ppm in the rain. As shown in the table 6a,dissolved oxygen of pond water ranged from 5.10ppm to 8.45ppm and 5.10ppm to 8.20ppm in pond 1 and pond 2 respectively. It is also evident from the table 6b,that yearly mean of the dissolved oxygen of the pond water was 6.32ppm in 2018 and 6.03ppm in 2019.The seasonal mean of dissolved oxygen was maximum 8.01ppm during winter and minimum 5.28ppm during summer.

Free Carbon Dioxide (ppm) : Table 7a shows that free CO_2 of the river water ranged from nil to 9.50ppm during the observation period of two years. The maximum value of free CO_2 9.50ppm was observed in the winter of 2019 at site-1 and minimum free CO_2 i.e.., nil in the winter of 2018,summer in 2018 and 2019 in winter in 2018 and 2019 at site-2 and in summer 2018 and 2019 at site-3. Table 7b shows yearly mean of the free CO_2 of the river water 2.36ppm in 2018 and 4.61ppm in 2019.The seasonal mean of the free CO2 was maximum 7.08ppm in the rain and minimum 0.88 in the summer. As shown in the table 7a free CO_2 of pond water ranged from nil to 13.42ppm and nil to 12.40ppm in pond 1 and pond 2 respectively. It is also evident from the table 7b, that yearly mean of the free CO_2 of the pond water was 5.91 ppm in 2018 and 4.30ppm in 2019.The seasonal mean of free CO_2 was maximum 11.53ppm during rain and minimum nil summer.

Table 6a : Observed Dissolved Oxygen (ppm) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	6.30	6.25	6.60	5.40	5.55
	2019	8.30	9.25	9.40	5.10	5.10
Rain	2018	6.10	5.70	6.00	5.25	5.10
	2019	6.20	6.50	7.40	6.10	6.10
Winter	2018	9.40	8.40	10.00	8.45	8.20
	2019	9.50	8.30	9.10	7.70	7.70

Table 6b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	7.19 ± 1.62	8.22 ± 1.62	7.68 ± 1.48	6.32 ± 0.66	9.12 ± 0.66
Pond (both ponds)	6.33 ± 1.56	6.30 ± 1.17	5.29 ± 0.23	5.64 ± 0.54	8.01 ± 0.38

Table 7a : Observed Free Carbon dioxide (ppm) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	3.30	0.00	0.00	0.00	0.00
	2019	2.00	0.00	0.00	0.00	0.00
Rain	2018	6.60	6.20	5.20	10.00	10.30
	2019	8.00	7.40	9.10	13.40	12.40
Winter	2018	0.00	0.00	0.00	7.50	7.70
	2019	9.50	0.00	5.50	0.00	0.00

Table 7b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	2.37 ± 2.95	4.61 ± 2.95	0.88 ± 1.43	7.08 ± 4.07	2.50 ± 4.07
Pond (both ponds)	5.92 ± 4.72	4.30 ± 6.67	0.00 ± 0.00	11.53 ± 1.64	3.80 ± 4.39

Carbonate Alkalinity (ppm) : Table 8a shows that carbonate alkalinity of the river water ranged from nil to 16.0ppm during the observation period of two years. The maximum value of carbonate alkalinity 16.0ppm was observed in the winter of 2018 at site -1 and minimum carbonate alkalinity nil was found in most of other observation sites during 2018. Table 8b shows yearly mean of the carbonate alkalinity of the river water 4.68ppm in 2018 and 1.67ppm in 2019.The seasonal mean of carbonate alkalinity was maximum 7.01ppm in the winter and minimum nil in the rain. As shown in the table 8a, carbonate alkalinity of pond water ranged from ppm to nil and 17.30ppm and nil to 18.10ppm in pond 1 and pond 2 respectively .It is also evident from the table 8b, that yearly mean of the carbonate alkalinity of the pond water was 5.09ppm in 2018 and 10.86ppm in 2019.The seasonal mean of carbonate alkalinity was maximum 16.32ppm during summer and minimum nil during rain.

Table 8a : Observed Carbonate (ppm) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	0.00	4.10	4.10	17.30	18.10
	2019	0.00	3.70	3.30	14.50	15.40
Rain	2018	0.00	0.00	0.00	0.00	0.00
	2019	0.00	0.00	0.00	0.00	0.00
Winter	2018	16.00	8.00	10.00	0.00	0.00
	2019	0.00	8.10	0.00	17.30	18.00

Table 8b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	4.69 ± 5.65	1.68 ± 5.65	2.53 ± 1.98	0.00 ± 0.00	7.02 ± 6.17
Pond (both ponds)	5.90 ± 9.14	10.87 ± 8.51	16.33 ± 1.66	0.00 ± 0.00	8.83 ± 10.19

Bicarbonate (ppm) : Table 9a shows that Bicarbonate of the river water ranged from 96ppm to 193ppm during the observation period of two years . The maximum value of Bicarbonate 193.0ppm was observed in the rain of 2019 at site-3 and minimum Bicarbonate 96 ppm was found in 2018 in summer at site-1. Table 9b shows yearly mean of the bicarbonate of the river water 130.44ppm in 2018 and 153.33ppm in 2019. The seasonal mean of bicarbonate was maximum 160.05 ppm in the winter and minimum 109.33ppm in the summer. As shown in the table 9a bicarbonate of pond water ranged from 94.30ppm to 145.36 ppm and 95.20ppm to 145.20ppm in pond 1 and pond 2 respectively. It is also evident from the table 9b that yearly mean of the bicarbonate of the pond water was 121.56ppm in 2018 and 124.29ppn in 2019. The seasonal mean of bicarbonate was maximum 139.28ppm during summer and minimum 103.72 ppm during winter.

Total Hardness (ppm) : Table 10a shows that total hardness of the river water ranged from 105.0ppm to 174.0ppm during the observation period of two years. The maximum value of total hardness 174.0ppm was observed in the winter of 2019 at site-1 and minimum bicarbonate 105.0ppm was found in 2018 in rain at site -1. Table 10b shows that yearly mean of the total hardness of th river water 126.00ppm in 2018 and 147.77ppm in 2019.The seasonal mean of total hardness was maximum 146.66ppm in the winter and minimum 122..05ppm in the summer. As shown in the table10a total hardness of pond water ranged from 94.0ppm to 152.30ppm and 94.50ppm to 155.10ppm in pond 1 and pond 2 respectively. It is also evident from the table 10b that yearly mean of the total hardness of the pond water was 120.16ppm in 2018 and 118.51ppn in 2019. The seasonal mean of total hardness was maximum 145.75ppm during rain and minimum 103.27ppm during summer.

Table 9a : Observed Bicarbonate (ppm) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	96.00	95.00	115.00	132.50	134.00
	2019	110.00	115.00	125.00	145.36	145.00
Rain	2018	134.00	140.00	110.00	115.00	122.00
	2019	175.00	183.00	193.00	130.00	135.00
Winter	2018	110.00	183.00	191.00	115.00	110.00
	2019	154.00	160.00	165.00	94.30	95.20

Table 9b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	130.44 ± 35.44	153.33 ± 35.44	109.33 ± 11.78	155.83 ± 32.60	160.50 ± 28.46
Pond (both ponds)	121.42 ± 9.94	124.14 ± 23.52	139.22 ± 6.92	125.50 ± 8.81	103.63 ± 10.46

Table 10a : Observed Total Hardness (ppm) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	110.00	120.00	120.00	94.00	94.50
	2019	120.00	135.00	130.00	115.40	109.20
Rain	2018	122.00	132.00	110.00	152.30	155.10
	2019	160.00	165.00	160.00	140.50	135.00
Winter	2018	105.00	160.00	155.00	115.00	110.10
	2019	174.00	135.00	151.00	103.00	107.30

Table 10b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	126.00 ± 19.60	147.78 ± 19.60	122.50 ± 8.80	141.50 ± 23.24	146.67 ± 24.02
Pond (both ponds)	120.17 ± 27.29	118.40 ± 15.61	103.28 ± 10.73	145.73 ± 9.55	108.85 ± 5.03

Calcium (ppm) : Table 11a shows that calcium of the river water ranged from 14.03ppm to 28.05ppm during the observation period of two years. The maximum value of calcium 28.05ppm was observed in the rain of 2019 at site-1 and minimum calcium 14.03ppm was found in 2018 in summer at site-1. Table 11b shows yearly mean of the calcium of the river water 26.52ppm in 2018 and 22.05ppm in 2019.The seasonal mean of calcium was maximum 32.04ppm in the winter and minimum 18.52ppm in the summer. As shown in the table 11a calcium of pond water ranged from 12.45ppm to 28.70ppm and 12.10ppm to 27.60ppm in pond 1 and pond 2 respectively. It is also evident from the table 11b that yearly mean of the calcium of the pond water was 15.93 ppm in 2018 and 20.55ppmin 2019.The seasonal mean of calcium was maximum 24.98ppm during summer and minimum 14.76ppm during rain.

Magnesium (ppm) : Table 12a shows that magnesium of the river water ranged from 8.75ppm to 28.13ppm during the observation period of two years. The maximum value of magnesium 28.13ppm was observed in the rain of 2019 at site-2 and minimum magnesium 8.75ppm was found in 2018 in rain at site-1. Table 12b shows yearly mean of the magnesium of the river water 15.67ppm in 2018 and 21.44ppm in 2019.The seasonal mean of magnesium was maximum 20.50ppm in the rain and minimum 16.46ppm in the winter. As shown in the table 12a magnesium of pond water ranged from 9.50ppm to 29.80ppm and 10.0ppm to 29.10ppm in pond 1 and pond 2 respectively.It is also evident from the table 12b that yearly mean of the magnesium of the pond water was 19.07ppm in 2018 and 16.78ppm in 2019.The seasonal mean of magnesium was maximum 26.8ppm during rain and minimum 10.17ppm during summer.

Table 11a : Observed Calcium (ppm) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	14.03	22.50	17.02	22.44	21.20
	2019	16.02	27.45	14.55	28.70	27.60
Rain	2018	19.01	18.01	39.20	12.45	14.20
	2019	28.05	21.06	8.04	15.30	17.10
Winter	2018	28.04	41.65	39.25	13.20	12.10
	2019	34.45	26.44	22.41	17.52	17.10

Table 11b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	26.52 ± 10.87	22.05 ± 10.87	18.60 ± 5.29	22.23 ± 10.51	32.04 ± 7.62
Pond (both ponds)	15.93 ± 4.63	20.55 ± 5.94	24.99 ± 3.72	14.76 ± 1.95	14.98 ± 2.73

Table 12a : Observed Magnesium (ppm) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	18.25	16.01	19.29	9.50	10.00
	2019	19.50	16.40	22.80	11.10	10.10
Rain	2018	18.40	21.70	10.95	29.80	29.10
	2019	21.93	28.13	21.90	25.10	23.20
Winter	2018	8.75	13.60	14.10	20.40	19.40
	2019	21.90	17.06	23.40	15.20	16.20

Table 12b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	15.67 ± 4.19	21.45 ± 4.19	18.71 ± 2.47	20.50 ± 5.64	16.47 ± 5.50
Pond (both ponds)	19.70 ± 8.82	16.82 ± 6.17	10.18 ± 0.67	26.80 ± 3.17	17.80 ± 2.49

Chloride(ppm) :

Table 13a shows that chloride of the river water ranged from 7.30ppm to 21.0ppm during the observation period of two years.The maximum value of chloride 21.0ppm was observed in the winter of 2019 at site-1 and minimum chloride 7.30ppm was found in 2018 in rain at site-1. Table 13b shows yearly mean of the chloride of the river water 10.41ppm in 2018 and 12.92ppm in 2019.The seasonal mean of chloride was maximum 13.93ppm in the winter and minimum 10.36ppm in the summer. As shown in the table 13a chloride of pond water ranged from 37.60ppm to 124.20ppm and 55.20ppm to 122.30ppm in pond 1 and pond 2 respectively.It is also evident from the table 13b that yearly mean of the chloride of the pond water was 75.07ppm in 2018 and 78.55ppm in 2019.The seasonal mean of chloride was maximum 117.24ppm during rain and minimum 45.25ppm during winter.

Silicate(ppm) : Table 14a shows that silicate of the river water ranged from 15.50ppm to 24.00ppm during the observation period of two years.The maximum value of silicate 24.0ppm was observed in the rain of 2018 at site-2 and minimum silicate 15.50ppm was found in 2019 in summer at site-3. Table 14b shows yearly mean of the silicate of the river water 19.05ppm in 2018 and 20.12ppm in 2019.The seasonal mean of silicate was maximum 21.46ppm in the winter and minimum 17.06ppm in the rain. As shown in the table 14a silicate of pond water ranged from 14.0ppm to 30.0ppm and 13.70ppm to 29.0ppm in pond 1 and pond 2 respectively. It is also evident from the table 14b that yearly mean of the silicate of the pond water was 22.88ppm in 2018 and 23.63ppm in 2019.The seasonal mean of silicate was maximum 29.15ppm during winter and minimum 14.55ppm during rain.

Table 13a : Observed Chloride (ppm) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	9.20	9.50	10.40	61.40	61.00
	2019	8.10	12.70	12.30	74.30	75.10
Rain	2018	7.30	9.20	9.60	110.27	112.20
	2019	12.10	12.00	14.00	124.20	122.30
Winter	2018	16.00	8.00	14.50	50.40	55.20
	2019	21.00	12.00	12.10	37.60	37.80

Table 13b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	10.41 ± 2.91	12.92 ± 2.91	10.37 ± 1.81	10.70 ± 2.43	13.93 ± 4.40
Pond (both ponds)	75.08 ± 28.31	78.55 ± 38.38	67.95 ± 7.80	117.24 ± 7.02	45.25 ± 8.94

Table 14a : Observed Silicate (ppm) of water of the river and pond water

Season	Year	River (Bagmati)			Ponds	
		Site I	Site II	Site III	Pond-I (Harahi)	Pond II (Ganga Sagar)
Summer	2018	19.20	19.40	19.30	25.40	22.20
	2019	22.30	23.50	15.50	27.00	26.70
Rain	2018	16.10	15.50	17.00	14.00	13.70
	2019	18.50	19.30	19.20	15.30	15.20
Winter	2018	22.60	24.00	19.40	30.00	29.00
	2019	19.60	22.00	21.20	29.50	28.10

Table 14b : Yearly and Seasonal mean of the river and pond water

Water bodies	Yearly Mean		Seasonal mean		
	2018	2019	Summer	Rain	Winter
Bagmati River (all sites)	19.17 ± 2.80	20.12 ± 2.80	19.87 ± 2.80	17.60 ± 1.63	21.47 ± 1.78
Pond (both ponds)	22.38 ± 7.16	23.63 ± 6.57	25.33 ± 2.20	14.55 ± 0.82	29.15 ± 0.81

DISCUSSION:

All the organisms including man are dependent on the environment of their habitat. They grow and their qualities are developed in a congenial environment. Any environment consist of biotic and abiotic components functioning together as a system known as "ecosystem". Both biotic and abiotic components interact to produce an exchange of material .Not only interaction between the above two components take place but interactions against different factors of both the components also takes place. Abiotic environment of fresh water ecosystem consist pf physic-chemical nature of the water.

The physico-chemical analysis of the pond and river water have been made during different season of two years of observation. The detail of observation may be discussed in relation to the previous works done by the different workers.

Yearly mean of the pH was observed higher in pond water in comparison to river water were as seasonal mean was same in pond and river water during the summer but lower in river water during winter. pH is among the most important and commonly studied properties of the natural water It is a measure of the level or intensity of acidic or basic character or the level of hydrogen ion activity . The pH of water in nature varies widely due to the mixing of mainly acidic and basic salts. Most commonly it varies between 6 and 8 .In commonest water, pH is slightly alkaline due to the presence of bicarbonates and carbonates of alkaline earth. Seulpthorpe (1976) has suggested that pH and carbon dioxide are even more critical factors in the survival of aquatic plant and fishes then the oxygen supply. Alternations in pH in natural waters are usually accompanied by changes in other physico-chemical factors also. It is therefore very essential to monitor the level of pH in a given water body regularly in view of its implication. Its level fluctuated in within a narrow range in conformity with the findings of various workers (Vyan and Kumar,1968;Singh and Swaroop,1979;Hosmani and Bharati,1980;Weimin and Xizoming,1987; Duncan and Blinn,1989;Mesfin and Belay,1989 and Surabhi,1994). Values of pH are within the limits prescribed by WHO and Ministry of Works and Housing, Government of India for drinking water.

`Temperature is amongst one of the important factors that has direct effect over the survival and existence of living organisms as well as physico-chemical quality of water. Temperature of the river and pond water showed typical seasonal fluctuation as it was recorded maximum in summer and minimum in winter. Yearly mean of the temperature was observed higher in pond water in comparison to river water whereas seasonal mean was higher in pond water during the summer but lower in winter. Vyas and Kumar (1968) have found similar results. The term transparency, visibility and turbidity are approximately equivalent terms and refer to the clarity of the water. Transparency of the water is the indicator of its physico-chemical status and activities of the aquatic lives are also being influenced to great extent through it.

Yearly mean of transparency was higher in river water as compared to pond water whereas seasonal was maximum in winter and minimum in rain. The low annual mean value of transparency of pond water may be attributed to heavy suspension of dissolved solids and profuse phytoplanktonic growth. Review of literature on transparency shows a great deal of variation regarding the months of its maxima and minima (Vyas and Kumar, 1968 ;Kant and Anand,1978;Surabhi, 1994;Nasar and Nasar,1978 and Yadava et al., 1987). Higher transparency in winter was also reported by Bhatt et al.(1985).However, Towhead et al. (1988) observed maximum transparency during the winter. Minimum transparency was observed during the rains, has also been observed by several investigators including Bhatt et al. (1985) and Towhead et al. (1988). Water becomes a conductor of electric current when substances are dissolved in it and its conductivity is proportionate to the amount of the substances dissolved in it. These substances are the ions which acts as conductor. The ability of conductance is dependent upon the concentration, mobility and valency of ions. Temperature of the medium also regulates it. Inorganic substances show better conductance as compare to organic compounds. Thus conductivity gives us a good idea of ionic concentration of dissolved substances. Conductivity measurement is useful in monitoring the total salt level in pure water supply line, in river, lakes and ponds and effluent discharge channels.

Yearly mean of conductivity was higher in pond water as compared to the river water but trend was reverse in the second year of observation. Seasonal mean of conductivity of river water was maximum in winter and minimum in the summer where as it was maximum during rain and minimum during winter in pond water. Bilgrami et al.(1979), Sabater et al.(1987),Reddy and Venkateswarlu (1987) and Rana and Palaria (1988) have reported higher value of conductivity for polluted habitats.

Total Dissolved Solids (TDS) include both the suspended and dissolved solids. Water with high solid content is inferior and may be polluted. Yearly mean of conductivity was higher in pond water as compared to the river water but trend was reverse in the second year of observation. Seasonal mean of conductivity of river water was maximum in winter and minimum in the summer where as it was maximum during rain and minimum during winter in pond water. Rana and Palria (1988) recorded increase in TDS values with increasing pollution in river Ayad,Udaipur.Pandey and Tripathy (1998) also observed higher annual average of TDS in two polluted ponds at Kanpur. Bilgrami et al. (1979) and Sangar et al.(1985) are also of the opinion that TDS value increases with increasing pollution.

Oxygen is one of the most important factors in any aquatic system. All aerobic organisms require oxygen for their respiratory activities .Terrestrial plant and animal get it easily because it is abundant and freely present in the air. However,in water it is available from a small stock held in dissolved form. The main source of dissolved oxygen in any water body is from the atmosphere and from photosynthesis of the aquatic green plants.The amount of oxygen in water depends on the surface area exposed, temperature and salinity.Dissolved Oxygen is an important parameter for assessing water quality.Water,where organic matter is very high,has very little oxygen dissolved in it and self-purification of water system depends on the presence of sufficient amount of season dissolved in it.When oxygen is used up faster than it is replaced, the water quality begins to deteriorate. Yearly mean of dissolved oxygen was observed higher in river water as compared to the pond water. Seasonal mean of Dissolved Oxygen was maximum in winter in both the river and pond water .Minimum dissolved oxygen in river water was recorded in rainy season but in pond water during summer. Dissolved Oxygen was found to be maximum during the winters .This can be attributed to the prevailing lower temperature. Solubility of oxygen is dependent on temperature and it increases with decrease in water temperature (Clarke ,1965). Higher amount of dissolved oxygen during the winters have also been reported by Vyas and Kumar (1968), Bhatt et al. (1985), Voulgaropoulous et al. (1987) and Towheed et al. (1988). Minimum content of Dissolved Oxygen was observed during the rains and summers , a result also observed by Das and Pandey (1978) , Singh and Swaroom (1979), Bhatt et al. (1985) , Mallick and Bose (1987), Verma and Munshi (1987) and Towheed et al. (1988).

Carbon dioxide in free form is usually abunding in standing and flowing fresh water.In lakes,ponds and rivers,CO_2 content of surface water may fall down with rise in pH due to CO2 consumption during photosynthesis. Yearly mean of free CO_2 was higher in pond water in the first year but a bit lower I the second year as compared to river water. Seasonal mean was maximum during the rain and minimum during summer. Free CO_2 was consistently present only during the rains which can be due to the decrease photosynthetic activities because of low density of phytoplankton Free CO2 was recorded above the ISI tolerance limit (6ppm) on several occasions. Water with concentration of free CO2 less than 5ppm supports good fish production, where as its high concentration in water leads to asphyxiation and obtain death of fishes (Chow,1958). As far as prediction of the trophic status of a water body on the basis of recording of annual mean values of free CO_2 is concerned , there are difference in opinions.Yadava et al.(1987) and Hosmani (1998) have observed decrease value of free CO_2 in eutrophic and polluted water bodies and on the other hand Hosmani and Bharti (1980) , Rana and Palria (1998) ,Mesfin and Belay (1989) have ascertained lower free CO_2 content at unpolluted sites . Thus, CO2 concentration appears to be no yard stick for predicting either the trophic level or magnitude of pollution of any water body.

Alkalinity is a measure of capacity of water to neutralize an acid. Water is said to be alkaline when the concentration of hydroxyl ion exceeds that of hydrogen ion.It is generally imparted by the salts of carbonates, bicarbonates , phosphates , nitrates , borates and silicates etc . together with the hydroxyl ions in free state.

Yearly mean of the carbonate alkalinity was higher in pond water as compared to the river water. Seasonal mean was maximum in winter and summer in the river water and pond water respectively, and minimum during the rains in both the river and pond water. Yearly mean of the bicarbonate alkalinity was higher in river water as compared to the pond water. Seasonal mean was maximum in winter and minimum in summer in river water but the trend was just reverse in pond water. Carbonate alkalinity was low whereas bicarbonate alkalinity was recorded fairly high. The lower levels carbonate alkalinity and higher level of bicarbonate alkalinity can be attributed to the pH range which favours more CO_2 to be present as HCO_3 ion (Clarke, 1965). High value of bicarbonate alkalinity in polluted water have been reported by Khan and Seenayya (1982), Prasad and Singh (1982),Venu et al. (1984), Singh (1985) and Sahay et al. (1985).Based on alkalinity values, Moyle (1946) classified water into three categories : low productive with less than 20 ppm alkalinity, low to medium with 20-40 ppm alkalinity and medium to high with 40-90ppm alkalinity. Philipose (1959) categories Indian water as low productive having 40-50 alkalinity, moderately high with 50-100 ppm alkalinity and fairly high with 100-200 ppm alkalinity. On the basis of these classifications, the river and pond under study appear to be of good productive value. The property of water which prevents leather formation with soap is called hardness and is mainly caused by the calcium and magnesium cations. However, other cations and anions also contribute to hardness. Hard water is not suitable for various domestic purposes. It has no adverse effect on health but highest desirable limit of 100 mg/l and maximum permissible limit of 500 mg/l have been set by WHO for drinking water. However, Ministry of Works and Housing (1975) considers 200 mg/l as acceptable and a concentration of 600 mg/l as cause of rejection.

Yearly mean of hardness was found to be higher in the river water as compared to pond water. Maximum seasonal mean was observed in winter and rain in river and pond water respectively, wher as the minimum was observed during summer in both the cases. As per the highest desirable standard of WHO 100 ppm the level of total Hardness was recorded above with at all the sites through out the observation period but the values were below the acceptable standard (200 ppm) of Ministry of Works and Housing (1975).Sawyer (1960) consider water with less than 75 mg/l of CaCO3 as soft and above it as hard, Moyle (1946), Yadava (1987) and Singh (1992) are of the opinion that alkalinity higher than 40 ppm appears to be reasonably good chemical dividing line between hard and soft water. On the basis of these classifications, the river and pond under study appear to be have hard water.

Calcium is an essential element for plant and animals, being a constituent of plant cell-wall in the form of calcium pectate and bones in man and animals. This element is quite abundantly found dissolved in water because of the abundance of calcareous rocks throughout the world. Water running across such rocks, dissolve calcium in form of bicarbonates. Besides natural sources industries and city sewage may also contribute calcium to the water body. Calcium is probably the most variable ion in most fresh water, lakes and streams Soft water may contain less than 1 mg/l of calcium, where as hard water may contain up to 100 mg/l. Yearly mean of calcium was found to be higher in the river water as compared to pond water. Maximum seasonal mean was observed in winter and summer in river and pond water respectively, where as the minimum was observed during summer and rain in river and pond respectively. Khan and Seenayya (1985) reported relatively higher mean average of calcium content (78.18 mg/l) in an industrially polluted Hussain Sagar lake , Hyderabad. Hosmani (1988) analysed the water quality the water quality of a fresh water pond at Dharwar twice, first during 1972-74 when the pond exhibited the growth of 24 algal taxa with 54.85 ppm of calcium content and second during 1978-80 when the calcium concentration increased to 242.85 ppm but the spectrum of the algae decreased to a considerable extent. Mahadev et al. (2009) reported 68 mg/l and 88.4 mg/l calcium content in two ponds with 55236 and 192660 org/l of diatoms respectively. Considering the above facts, the calcium level of the river and pond water under consideration is not too high to cause pollution and the level of calcium content in pond water and river water is suitable for diatoms.

Magnesium is an important major nutrient needed by all organisms, since it activates many enzyme systems. It is an essential constituent of the chlorophyll and is also involved in phosphorus transfer process. It is particularly associated with clay. It plays an important role in synthesis of ATP and ADP and inorganic phosphates. It is also an activator for many of the enzymes involved in carbohydrate metabolism. In the present study, yearly mean of magnesium was found to be higher in the river water in first year of observation and lower in second year of observation when compared with respective pond water. Contrary to this, seasonal mean was found lower in the river water in first year of observation and higher in second year of observation when compared with respective pond water. The annual mean averages of magnesium contents of river were found to be 15.7 mg/l and 21.47mg/l and in pond water were 19.74ppm and 26.85 ppm in two years of observations respectively. The highest desirable limit of magnesium in drinking water prescribed by WHO and acceptable limit to Ministry of Works and Housing is 30ppm. Thus existing level of magnesium in pond and river water is within the maximum desirable limit of WHO and acceptable limit of Ministry of Works and Housing Prasad and Singh (1982) recorded higher values of magnesium of polluted station (35.36 ppm) in comparison with unpolluted station (17.13 ppm) of Gomati river at Lucknow. Singh et al.(1970) during their study of the algal flora of sewage recorded the range of magnesium between 15.4 and 85.0ppm. Singh (1992) recorded minimum magnesium level during monsoon months and the maximum in the month of February. Therefore, It may be concluded that the pond and river water under study is not polluted as far as magnesium is concerned.

Yearly and seasonal means of chloride of the river water were found quite less than that of pond water in both years of observations. None of the values exceeded desirable standard (200ppm) of WHO and Ministry of Works and Housing in the water of pond and river.High chloride content in the polluted water has been reported by Govindan and Sundaresan (1979) , Prasad and Singh (1982) , Venkateswarle and Sampath Kumar (1979) , Venue et al. (1984), Singh (1985), Manikya Reddy and Venkateswarlu

(1987) and Rana and Palria (1988). Somashekhar and Ramaswamy (1984) have reported positive co relation between content of chloride with population density of diatoms in the river Kapila.

Silicon is second only to oxygen in abundance in the earth crust. Natural waters contain silicon because of the dissolution of silicate minerals with which they come to contact. Silicon concentration in natural waters typically are reported in terms of SiO_2 and usually range from 5 to 25 mg/l in fresh water system (Claude, 2014). Annual average means of silicate content of the river water where found to be slightly lower than that of pond water under study during both years of observation. Maximum value of silicate was found in the rain of 2015 in the river water where as in pond water it was found maximum in winter. Kumar (1996) and Kumar and Bohara (2002) have found the average silicate content of pond system was slightly higher than that of river in the sites which is in contrast with observation of current study.

CONCLUSION

Observed values of pond water on pH, Temperature, Carbonate Alkalinity, Chloride and Silicate were found comparatively higher than that of river water, whereas Transparency, Dissolved Oxygen, Bicarbonate Alkalinity, Total Hardness, Calcium of pond water were found lower than the river water.

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