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Investigations on the Physic-Chemical Parameters and Bacterial Occurrence in Four Water Bodies of Bhopal, India

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Investigations on the Physic-Chemical Parameters and Bacterial Occurrence in Four Water Bodies of Bhopal, India

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Abstract - This study was carried out in four water bodies of Bhopal for a period of 2 years. Monthly changes in physic-chemical parameters such as air temperature, water temperature, total dissolved solids, hydrogen-ion concentration, dissolved oxygen, free carbon dioxide, phenolphthalein alkalinity, total alkalinity, chloride, calcium hardness and total hardness along with bacterial occurrence were studied. The results indicated changes in physic-chemical parameters and occurrence of bacteria depending on the different seasons of the year.

Keywords : physic-chemical parameters, water bodies, monthly changes.

I. Introduction

The physic-chemical parameters are of paramount importance for all the organisms living in water. Many researchers have carried out studies on these parameters in different places in India (Pant and Sharma, 1985; Pataki, 1990; Agawam, 1993; Katarina, *et al.*, 1994; Katarina and Irbil, 1995; Magarey *et al.*, 2006).

Bhopal, the city of lakes, is situated at 23°16' N latitude and 77°26' E longitude. It possesses a number of small and large water bodies including Hate knead reservoir, Lower Lake, Sapura Lake and Larrup reservoir. Hate knead reservoir is situated at 26°16' N latitude and 77°30' E longitude above 460m MSL. Lower lake is situated at 23°16' N latitude and 72°25' E longitude and is one of the twin lakes of Bhopal. Shah pure lake has a surface area of 0.96 sq km. This lake is situated at 23°12' 00" N latitude and 77°25' 30" E longitude. Larrup reservoir is situated at about 10 km away from Bhopal city and lies at 23°11' 45" N latitude and 77°28' 50" E longitude.

Aquatic environment is inhabited with numerous species of bacteria, many of which are responsible for causing dreaded diseases in fishes. Eutrophic water provides favorable habitat for their growth and proliferation because of the availability of nutrients and organic materials (Plumb, 1994). (Koyama and Taming, 1967; Chen, 1968; Fonder, 1969 and Jones, 1970) observed the decline in number and growth of bacteria during summer months which they considered due to high temperature and low concentration of nutrients. (Plumb, 1994) reported that moderate level of temperature is suitable for the growth and development of bacteria.

The present study was, therefore, conducted to investigate the physic-chemical parameters and bacterial occurrence keeping in view the different seasons of the year.

II. Materials and Methods

Important physic-chemical parameters like temperature, total dissolved solids, hydrogen-ion concentration, dissolved oxygen, free carbon dioxide, alkalinity, chloride and hardness of these water bodies were analyzed by the procedures of (APHA, 1995; Goblet roman, 1978 and Wetzel, 1979). Wherever necessary, the DREL / 2000 spectrophotometer, USA was also used for the purpose of water analysis.

For the purpose of isolation of bacteria from water, the samples were collected in sterilized bottles, once every month throughout the study period from five different locations of each water body. The isolation of bacteria from water samples was done following the methods of (Speck, 1976 and Collins and Lynne, 1985). The samples collected were serially diluted and each diluted sample was inoculated in the plates having different media by surface spread method (Speck, 1976). Upton 10 typical colonies selected from each duplicate set of plates were purified, confirmed and differentiated to the genus level.

III. Results and Discussion

During the study period, marked changes were observed in the temperature of all the four water bodies under investigation. Atmospheric temperature ranged between 18.0 to 35.0 °o near Hate knead reservoir, 17.0 to 35.0 °o near Lower lake, 18.0 to 35.0°C near Sapura lake and 18.0 to 35.0°C near Larrup reservoir. The water temperature of Hate knead reservoir, Lower lake, Sapura lake and Larrup reservoir ranged between 20.0 to 30.0°C, 20.0 to 31.0°C, 20.0 to 30.0°C and 20.0 to 30.0°C, respectively. The occurrence of bacterial

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species showed negative relationship with atmospheric and water temperature in all the water bodies except Larrup reservoir where it showed positive relationship. It has been observed that the moderate temperature was more conducive for the occurrence of aquatic bacteria. This finding gets support from the work of (Plumb, 1994; Rodgers and Burke, 1981; Roberts *et al*., 1986 and Virginal, 1992).

Total dissolved solids ranged between 86.0 to 135.0 mg/l in Hate iced reservoir, 104.0 to 198.0 mg/l in Lower Lake, 86.0 to 135.0 mg/l in Sapura lake and 103.0 to 172.0 mg/l in Larrup reservoir. The occurrence of bacterial species indicated negative relationship with total dissolved solids in Lower lake and Larrup reservoir and positive relationship in Hate iced reservoir and Sapura lake.

pH ranged between 7.5 to 9.0 in Hate knead reservoir, 7.3 to 9.0 in Lower lake, 7.5 to 9.0 in Sapura lake and 7.0 to 8.4 in Larrup reservoir. The occurrence of bacterial species indicated negative relationship with pH in all the water bodies except Hate iced reservoir where it showed positive relationship.

Dissolved oxygen was found to range between 6.4 to 9.1 mg/l in Hate knead reservoir, 5.0 to 9.4 mg/l in Lower lake, 6.4 to 9.1 mg/l in Sapura lake and 5.4 to 10.0 mg/l in Larrup reservoir. Higher dissolved oxygen values observed during winter were due to low temperature and during summer due to the photosynthetic activities. The same have also been the observations of (Sir invasion, 1996; Sashay and Sinhala, 1969; Agawam *et al*., 1976 and Ray, 1978) in this regard. (Roberts *et al*., 1986) have reported occasional low oxygen concentrations in several organically enriched environments. The occurrence of bacterial species indicated positive relationship with dissolved oxygen in all the water bodies except Larrup reservoir where it showed negative relationship.

Free carbon dioxide was present in Hate iced only in July, 2004 and 2005. It ranged between 4.6 to 14.9 mg/l in Lower Lake, 9.5 to 19.2 mg/l in Sapura lake and 9.2 to 19.3 mg/l in Larrup reservoir. The occurrence of bacterial species showed positive relationship with free carbon dioxide in Sapura Lake and Larrup reservoir; negative relationship in Lower Lake and no relationship at all in Hate knead reservoir. Phenolphthalein alkalinity ranged between 6.3 to 15.3 mg/l in Hate iced reservoir, 6.5 to 18.2 mg/l in Lower Lake and 6.4 to 10.2 mg/l in Larrup reservoir. The occurrence of bacterial species showed positive relationship with phenolphthalein alkalinity in Lower lake and Larrup reservoir; negative relationship in Hate knead reservoir and no relationship at all in Sapura Lake.

Total alkalinity ranged between 60.0 to 186.0 mg/l in Hate iced reservoir, 110.0 to 262.0 mg/l in Lower Lake, 60.0 to 186.0 mg/l in Sapura Lake and 124.0 to 210.0 mg/l in Larrup reservoir. The occurrence of bacterial species showed negative relationship with total alkalinity in all the four water bodies.

Chloride values ranged between 14.0 to 35.0 mg/l in Hate knead reservoir, 18.5 to 56.0 mg/l in Lower Lake, and 14.0 to 35.0 mg/l in Sapura Lake and 25.0 to 38.0 mg/l in Larrup reservoir. Higher chloride values were observed in Lower Lake as compared to those of Hate iced reservoir, Sapura Lake and Larrup reservoir. Comparatively, lower values were obtained during monsoon and higher during summer months. Similar seasonal trend of fluctuation in chloride values is also reported by (Paha and Mohr okra, 1966; Mathew, 1969 and Agawam *et al*., 1976). Higher concentration of chloride is an indicator of pollution due to high organic waste of animals (Thresh *et al*., 1944). The occurrence of bacterial species exhibited negative relationship with chloride in all the four water bodies.

Calcium hardness ranged between 85.0 to 138.0 mg/l in Hate kneads reservoir, 71.0 to 167.0 mg/l in Lower Lake, and 85.0 to 139.0 mg/l in Sapura Lake and 69.0 to 174.0 mg/l in Larrup reservoir. The occurrence of bacterial species showed negative relationship with calcium hardness in all the water bodies except Lower Lake where it showed positive relationship.

Total hardness ranged between 110.0 to 240.0 mg/l in Hate kneads reservoir, 101.0 to 240.0 mg/l in Lower Lake, 154.0 to 243.0 mg/l in Sapura lake and 115.0 to 298.0 mg/l in Larrup reservoir. The occurrence of bacterial species showed negative relationship with calcium hardness in Hate iced reservoir and Sapura lake while it showed positive relationship in Lower lake and Larrup reservoir.

It was observed that the occurrence and abundance of aquatic bacteria varied from time to time depending on the availability of nutrients and prevailing physico-chemical parameters. The bacteria isolated represented mainly the families *Bacillaceae, Cytophagaceae, Enterobacteriaceae, Micrococcaceae, Pseudomonadaceae* and *Streptococcaceae*. Of the total bacteria isolated, *Aeromonas, Acinetobacter*, Bacillus, *Cytophaga, Escherichia, Flexibacter*, Micrococcus, Pseudomonas, Staphylococcus and Streptococcus were the common genera found in all the water bodies.

Abundant occurrence of bacteria was recorded during and after rainy season in all the four water bodies. It might be due to the influx of large volume of sewage loaded with bacteria and other organic material. This finding gets support from the observations of (Fred et al., 1924; Taylor, 1949 and Collins, 1963). Decrease in the number of bacteria is noticed during summer months which might be due to high temperature and low nutrient level. Similar findings are reported by (Koyama and Domino, 1967; Chen, 1968; Fonder, 1969 and Jones, 1970).

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Table 1 : Physic-chemical parameters of Hate iced reservoir (August 2003-July 2005)

Month	AT °C	WT °C	TDS (mg/l)	pH	DO (mg/l)	Free CO_2 (mg/l)	PA (mg/l)	TA (mg/l)	Chloride (mg/l)	CH (mg/l)	TH (mg/l)
Aug	27	28	101	7.5	7.1	0	4.2	110	26	1.5	188
Sep	29	27	113	7.6	6.9	0	6.3	82	24	111	199
Oct	27	26	127	7.9	7.4	0	8.7	62	22	119	210
Nov	24	23	130	8.0	7.7	0	9.5	83	20	133	299
Dec	22	24	119	8.4	7.9	0	11.8	105	16	138	240
Jan	19	21	98	8.6	8.5	0	8.4	111	17	108	191
Feb	21	22	88	8.8	9.1	0	12.5	123	19	103	172
Mar	25	23	94	8.3	6.7	0	9.7	131	23	117	201
Apr	30	27	101	8.1	6.9	0	12.8	145	33	123	213
May	35	29	115	7.9	7.2	0	14.7	179	31	109	194
Jun	31	28	121	7.6	7.5	0	11.3	147	29	96	142
Jul	29	27	130	7.9	7.1	6.4	0	122	28	87	119
Aug	26	25	96	7.6	7.2	0	4.9	116	27	102	182
Sep	28	26	120	7.8	7.0	0	6.8	84	22	108	193
Oct	28	27	131	8.2	7.6	0	9.3	60	19	122	218
Nov	25	24	128	8.4	7.9	0	102	85	17	129	221
Dec	21	23	114	8.7	8.2	0	12.5	109	14	132	237
Jan	18	20	102	8.8	8.6	0	8.3	116	18	105	117
Feb	20	21	86	9.0	9.0	0	12.7	130	21	101	157
Mar	25	23	96	8.6	6.4	0	9.0	139	29	112	204
Apr	29	25	105	8.4	6.8	0	13.1	148	35	128	221
May	34	28	118	8.2	7.0	0	15.3	186	33	106	181
Jun	31	27	123	7.8	7.8	0	12.9	156	30	98	149
Jul	29	26	135	8.2	7.4	4.0	0	130	25	85	110

AT=Atmospheric temperature, WT=Water temperature, TDS=Total Dissolved Solids, DO=Dissolved Oxygen, PA=Phenolphthalein Alkalinity, TA=Total Alkalinity, CH=Calcium Hardness, TH=Total Hardness

Table 2 : Physic-chemical parameters of Lower lake (August 2003-July 2005)

Month	AT °o	WT °o	TDS (mg/l)	pH	DO (mg/l)	Free CO_2 (mg/l)	PA (mg/l)	TA (mg/l)	Chloride (mg/l)	CH (mg/l)	TH (mg/l)
Aug	27	25	115	7.3	5.8	5.2	0	168	52.3	158	208
Sep	28	26	119	7.4	5.4	6.0	0	148	42.4	167	280
Oct	30	27	132	7.7	5.0	0	12.0	115	33.8	122	194
Nov	26	24	124	8.1	6.4	0	7.8	128	28.2	111	167
Dec	22	24	113	8.2	8.2	8.4	0	137	21.5	102	143
Jan	18	21	109	7.4	8.8	10.1	0	143	19.2	88	127
Feb	22	23	104	7.7	9.4	12.8	0	162	23.2	75	109
Mar	28	26	148	8.1	7.2	14.9	0	194	28.8	93	138
Apr	31	28	162	8.5	6.7	0	6.5	235	36.7	106	157
May	35	30	194	8.8	6.1	0	10.2	262	55.6	117	173
Jun	31	27	171	8.3	7.3	0	17.8	213	45.0	132	198
Jul	29	26	138	8.0	6.5	8.6	0	192	51.8	145	201
Aug	26	23	118	7.3	5.9	4.6	0	175	54.0	160	271
Sep	28	26	125	7.6	5.5	6.2	0	154	44.2	155	204
Oct	29	25	136	7.9	5.2	0	12.2	110	38.0	134	199
Nov	25	22	122	8.2	6.4	0	8.0	121	31.5	115	181
Dec	21	23	116	8.0	8.0	8.5	0	128	24.6	100	134
Jan	17	20	112	7.4	8.4	10.4	0	140	18.5	83	121
Feb	21	24	106	7.6	8.8	12.5	0	166	20.0	71	101
Mar	27	25	156	8.0	6.4	14.6	0	197	27.2	89	130

Apr	30	28	164	8.8	6.3	0	7.0	232	38.0	105	159
May	34	29	198	9.0	6.2	0	10.4	246	56.0	120	182
Jun	32	28	178	8.5	6.8	0	18.2	210	48.2	137	203
Jul	30	27	142	8.2	6.0	8.5	0	196	52.2	149	211

AT=Atmospheric temperature, WT=Water temperature, TDS=Total Dissolved Solids, DO=Dissolved Oxygen, PA=Phenolphthalein Alkalinity, TA=Total Alkalinity, CH=Calcium Hardness, TH=Total Hardness

Table 3 : Physic-chemical parameters of Sapura lake (August 2003-July 2005)

Month	AT °C	WT °C	TDS (mg/l)	pH	DO (mg/l)	Free CO_2 (mg/l)	PA (mg/l)	TA (mg/l)	Chloride (mg/l)	CH (mg/l)	TH (mg/l)
Aug	27	26	92	7.6	7.2	14.9	0	116	27	102	182
Sep	29	27	120	7.8	7.0	16.8	0	84	22	108	193
Oct	27	25	131	8.2	7.6	19.2	0	60	19	122	208
Nov	26	24	128	8.4	7.9	10.3	0	85	17	139	221
Dec	22	24	114	8.7	8.2	11.7	0	109	14	132	215
Jan	19	22	102	8.8	8.6	12.1	0	116	18	105	189
Feb	22	24	86	9.0	9.0	12.6	0	130	21	101	176
Mar	25	23	96	8.6	6.4	13.0	0	139	25	112	201
Apr	29	27	105	8.4	6.8	13.9	0	148	35	128	216
May	35	30	118	8.2	7.0	15.2	0	186	33	106	193
Jun	31	28	123	7.8	7.8	12.5	0	156	30	98	178
Jul	29	27	135	8.2	7.4	11.4	0	130	29	85	154
Aug	28	26	101	7.5	7.1	14.2	0	110	26	105	188
Sep	30	27	113	7.6	6.4	16.3	0	82	24	111	199
Oct	28	24	127	7.9	7.1	18.7	0	62	22	119	210
Nov	25	23	130	8.0	7.7	9.5	0	83	20	133	220
Dec	21	23	119	8.4	7.9	11.3	0	105	16	138	243
Jan	18	20	98	8.6	8.5	11.8	0	111	17	108	195
Feb	20	22	89	8.8	9.1	12.2	0	123	19	103	187
Mar	25	23	94	8.3	6.7	12.7	0	131	23	117	205
Apr	28	26	101	8.1	6.9	13.4	0	145	33	123	212
May	34	29	115	7.9	7.2	14.7	0	179	31	109	199
Jun	32	28	121	7.6	7.5	11.6	0	147	29	96	164
Jul	30	27	132	7.9	7.1	10.2	0	122	28	87	157

AT=Atmospheric temperature, WT=Water temperature, TDS=Total Dissolved Solids, DO=Dissolved Oxygen, PA=Phenolphthalein Alkalinity, TA=Total Alkalinity, CH=Calcium Hardness, TH=Total Hardness

Table 4 : Physic-chemical parameters of Larrup reservoir (August 2003-July 2005)

Month	AT °C	WT °C	TDS (mg/l)	pH	DO (mg/l)	Free CO_2 (mg/l)	PA (mg/l)	TA (mg/l)	Chloride (mg/l)	CH (mg/l)	TH (mg/l)
Aug	29	26	131	7.1	7.4	14.2	0	139	33	147	276
Sep	30	28	157	7.2	6.9	13.5	0	124	29	172	294
Oct	28	26	159	7.5	6.3	16.7	0	146	25	109	183
Nov	25	22	132	7.6	7.9	18.2	0	141	28	99	165
Dec	22	23	119	7.8	7.2	19.3	0	133	30	93	133
Jan	18	20	103	7.5	7.1	15.8	0	147	37	69	115
Feb	21	22	111	7.3	6.9	13.0	0	159	29	102	178
Mar	26	24	116	8.1	6.5	11.5	0	173	33	114	185
Apr	30	27	143	8.4	9.2	0	7.2	182	35	120	215
May	34	29	157	8.3	5.8	0	8.9	163	37	141	254
Jun	32	29	128	7.9	5.4	0	9.7	201	34	156	273
Jul	30	26	117	7.5	6.2	0	7.7	158	35	170	289

Aug	28	25	124	7.0	7.2	12.7	0	150	28	152	282
Sep	30	26	172	7.3	6.6	10.8	0	130	26	174	298
Oct	27	25	166	7.7	6.4	18.5	0	148	27	118	202
Nov	24	23	148	7.9	8.2	14.9	0	142	28	110	188
Dec	20	22	140	7.5	8.0	16.3	0	130	29	102	175
Jan	19	21	110	7.2	7.6	12.8	0	151	38	75	122
Feb	22	23	122	7.4	7.2	10.0	0	165	27	106	186
Mar	27	25	130	8.3	7.0	9.2	0	180	34	120	219
Apr	31	27	160	8.1	10.0	0	6.4	194	33	124	227
May	35	30	170	8.6	6.0	0	9.8	178	37	140	251
Jun	33	29	140	8.2	5.6	0	10.2	210	30	159	282
Jul	31	28	115	7.2	6.8	0	8.5	170	32	163	291

AT=Atmospheric temperature, WT=Water temperature, TDS=Total Dissolved Solids, DO=Dissolved Oxygen, PA=Phenolphthalein Alkalinity, TA=Total Alkalinity, CH=Calcium Hardness, TH=Total Hardness

Table 5 : Mean and Standard Deviation of various ecological parameters and bacterial species

Parameters	Hate iced reservoir	Lower lake	Sapura lake	Larrup reservoir
Atmospheric temperature	26.38 ± 4.4517	26.96 ± 4.64	26.67 ± 4.459	27.17 ± 4.749
Water temperature	25.0 ± 2.5	25.29± 2.474	25.21 ± 2.449	25.29 ± 2.776
Conductivity	206.5 ± 29.67	278.71± 52.106	210.5 ± 33.29	283.03 ± 27.788
Total dissolved solids	112.17 ± 14.45	137.58 ± 27.28	112.08 ± 14.76	136.25 ± 20.33
Hydrogen-ion concentration	8.18 ± 0.4231	8.0 ± 0.4822	8.18 ± 0.4213	7.69 ± 0.4499
Dissolved oxygen	7.54 ± 0.7076	6.78 ± 1.2024	7.54 ± 0.7076	7.05 ± 1.04008
Free carbon dioxide	-	9.38 ± 3.225	13.34 ± 2.475	14.21 ± 2.97
Phenolphthalein alkalinity	10.22 ± 2.95	11.01 ± 3.962	-	8.55 ± 1.269
Total alkalinity	119.13 ± 32.14	173.83 ± 42.81	119.13 ± 32.14	158.92 ± 22.79
Chloride	24.08 ± 5.88	37.12 ± 12.52	24.08 ± 5.88	31.42 ± 3.817
Calcium hardness	111.54 ± 13.89	118.08 ± 27.58	111.96 ± 14.55	126. 46 ± 29.78
Total hardness	189.5 ± 33.81	174.63 ± 44.84	196.04 ± 20.74	220.13 ± 56.75
Bacteria	6.96 ± 1.6951	7.17 ± 1.95	7.46 ± 4.45	7.04 ± 1.989

Table 6 : Coefficient of Correlation between the occurrence of bacterial species and various ecological parameters

Parameters	Hate iced reservoir	Lower lake	Sapura lake	Larrup reservoir
Air temperature	- 0.23 (1.135)	-0.2247(1.081)	- 0.294 (1.445)	0.1227 (0.5801)
Water temperature	- 0.137 (0.651)	- 0.2603 (1.26)	-0.2191 (1.053)	0.12607 (0.5961)
Conductivity (µmhos/cm)	0.1313 (0.621)	- 0.3135 (1.548)	- 0.0849 (0.399)	-0.0518 (0.2436)
TDS (mg/l)	0.326 (1.622)	-0.4769 (2.545)*	0.0872 (0.410)	- 0.0661 (0.3111)
pH	0.0396 (0.186)	-0.5271(2.90)*	-0.1342 (0.6355)	- 0.3348 (1.666)
Dissolved oxygen (mg/l)	0.338 (1.68)	0.0902 (0.425)	0.389 (1.98)	- 0.5263 (2.90)*
Free CO_2 (mg/l)	-	- 0.285 (1.030)	0.129 (0.6101)	0.2980 (1.16)
Phenolphthalein alkalinity (mg/l)	- 0.3009 (1.411)	0.484 (1.56)	-	0.684 (2.30)
Total alkalinity (mg/l)	- 0.425 (2.20)*	- 0.4795 (2.56)*	- 0.576 (3.31)*	- 0.1396 (0.6614)
Chloride (mg/l)	- 0.2922 (1.433)	- 0.064 (0.3036)	- 0.392 (1.99)	- 0.3095 (1.52)
Calcium hardness (mg/l)	- 0.3032 (1.49)	0.2165 (1.04)	- 0.2042 (0.978)	0.2725 (1.328)
Total Hardness (mg/l)	- 0.3442 (1.719)	0. 1797 (0.857)	- 0.1874 (0.894)	0.2435 (1.177)

*Values are significant at 5 % level