Physico-chemical parameters of Itahari sub-metropolitan fish pond, Nepal

Ganesh Bahadur Thapa¹ and Joydeb Pal²

¹Central Campus of Technology, Tribhuwan University, Dharan (Hattisar), Sunsari, Nepal
²Department of Zoology, University of North Bengal, Siliguri-734013, West Bengal, India
ganeshbdr13@gmail.com

ABSTRACT
Itahari Sub-metropolitan pond is located in the centre of the city. Influence of variations in physico-chemical parameters on aquatic flora and fauna especially in fishes brought strong stress on fishes and increases the incidence of diseases leading to high mortality. Due to lack of adequate knowledge about it, productivity of ponds is very low.

In the present study, maximum and minimum variations and correlation between different physico-chemical parameters - air temperature, water temperature, pH, turbidity, total dissolved solids, dissolved carbon dioxide, ammonia, dissolved oxygen, biological oxygen demand, chloride, total alkalinity, total hardness and phosphate were taken into consideration. The water quality of fish ponds were normal except high fluctuation of chloride 4.0 - 44.87 mg/l and ammonia 0.48-13.6 mg/l during manuaring period and casual addition of wastes like toilet cleaners, caustic potash etc.. Due to sudden fall in DO less than 4 mg/l during April and May, 2014 and increment of ammonia after addition of toilet wastes in Sept.19, 2015; mass mortality of fishes Labeo rohita, Cirrhina mrigala, Hypothalamichthys molitrix, Aristichthys nobilis occurred in the study site.

Keywords: Physicochemical, Itahari, fish, pond, environment, variations

INTRODUCTION
Nepal has four major perennial river systems: Koshi, Gandaki, Karnali and Mahakali. Around 6,000 rivers including tributaries and several lakes, swamps, ponds and streams are distributed throughout the country. The total water bodies occupy 2.8% of total area of the country. Natural water bodies consist of about 55% of total inland water resources. Due to the different altitudinal (Terai, Hills, Mountains within ranges between 200-4000 m) and climatological variation in water bodies, the various fish species (187 indigenous species) diversified (Shrestha, 2001), 232 species (Shrestha, 2008 ).

Though the potentiality of the extension of fish farming is very high, capture fisheries were much more (16700 MT/yr) than the production of cultured fish (10559 MT/yr) and total shares of fisheries in normal GDP is 0.81% (1999/2000). Later reported cultured fishery production increased to 26679 MT and captured fisheries to 20100 MT per year (DOFD, 2007). Total production of fish was 56,000 (36500 from aquaculture alone) Mt/year in the year 2012-2013 (Shrestha & Mishra, 2014).
The physico-chemical parameters of water bodies influence directly or indirectly the aquatic organisms in various ways. Functioning of the aquatic ecosystem is regulated by the interaction among the physico-chemical and biological components of the system. Hence, it is essential to have the knowledge of physico-chemical parameters for identifying suitability and fertility of an aquatic ecosystem. Reid (1961) stated that the successful development and maintenance of a population of organisms depends upon harmonious ecological balance between environmental conditions and tolerance of the organism to variations in one or more of these conditions. The physico-chemical parameters of a water body change due to seasonal change, diurnal changes and pollutants which influence in abundance of aquatic organisms. Among the physico-chemical parameters air temperature, water temperature, pH, dissolved oxygen (DO), free carbon dioxide (CO$_2$), T alkalinity (TA), T hardness (TH), chloride (Cl$^-$) and BOD mainly determine the hydrological condition of water body. Extensive works have been carried out by different workers (Bhowmik, 1988; Dobriyal & Singh, 1989; Patralekh, 1994; Singh & Singh, 1995; Mishra & Sharma, 1998; Ashok et al., 2007) on the physico-chemical and biological parameters of freshwater bodies in other countries.

In Nepal, Loffler (1969) reported the dominance of calcium among cations, low chloride and less than 1µg /l phosphorus from the high altitude lakes of Mount Everest region. Lohaman et al. (1988) studied pre and post monsoon limnological characteristics of lakes of Pokhara and Kathmandu valleys and obtained low alkalinity and conductivity in the lakes of Pokhara valley. McEachern (1994) reported 8.4 pH, 0.03 mg/l phosphate and 8.5 mg/l dissolved oxygen in Narayani, a lowland (< 1000 m) river of Nepal. Aryal & Lacoul (1996) reported high pH, total hardness, BOD at polluted site, where transparency and DO were low in Punyamati river. Ormerod et al. (1996) reported the pH range between 7.3 to 8, chloride 0.4 mg/l to 1.4 mg/l, nitrate 0.06 mg/l to 0.28 mg/l, and phosphate 0.02 mg/l to 0.04 mg/l from the highland (> 2000 m) rivers of Nepal. Niraula et al. (2010) revealed pH, conductivity, turbidity, total phosphorus and total alkalinity were higher in summer whereas total dissolved solids, nitrate, total hardness- CaCO$_3$, dissolved oxygen, BOD, and chloride content were higher in winter, however, water depth, temperature, ammonia and carbon dioxide were higher in rainy season. Also, more seasonal fluctuations in turbidity (0.76-26.01 NTU), carbon dioxide (4.58-73.92 mg/l) and chloride content (2.0-7.0 mg/l) was recorded in Betana pond, eastern Nepal.

MATERIALS AND METHODS

Study area

Present study area includes Itahari sub- metropolitan artificial pond is located at latitude 26°39’47.41” N and longitude 87°16’37.97”E occupied 18 kattha (3280.5 square feet) area of the city at the sub-metropolitan premises. The study deals with the physicochemical parameters - air temperature, water temperature, pH, dissolved carbon dioxide, dissolved oxygen, biological oxygen demand, chloride, total alkalinity, total hardness, ammonia and phosphate of Itahari sub-metropolitan pond during the first and the second year (November 2013 to October 2015).

Sampling

The site Itahari sub-metropolitan pond was selected in its premises. Parameters taken were air temperature, water temperature, pH, dissolved carbon dioxide, dissolved oxygen,
biological oxygen demand, chloride, total alkalinity, total hardness ammonia and phosphate following Trivedi and Goel (1984) and APHA (2005). During the study some physico-chemical parameters were studied on the spot e.g. DO, pH, temperature and CO$_2$. In addition, other parameters were analyzed in the laboratory by carrying water samples in closed bottles. Sampling was done at 8.00A.M. to 11.00 A.M. at the last week of each month. Whole year was divided into three seasons – summer (March-June), rainy (July-October) and winter season (November-February). Monthly data of different parameters were pooled into seasonal data. Standard deviation, correlation coefficient were calculated by using Microsoft excel statistical function of computer software. The correlation coefficient between different variables was calculated and their significance differences were tested using SPSS.

RESULTS AND DISCUSSION

Results of the air temperature and physico-chemical parameters of water of Itahari sub-metropolitan pond are shown in table 1 and table 2. Table 1 shows the results of air temperature and physico-chemical parameters of water of the first year (November 2013 to October 2014) and table 2 shows the second year (November 2014 to October 2015) of the study periods. The seasonal variations in air temperature, water temperature and physico-chemical parameters of the site in different seasons during first and second year study period are tabulated in table 4.
TABLE 1. Air and water temperature and physico-chemical parameters of water recorded at Itahari municipality pond during November 2013 to October 2014 (Mean±S.D., N=5).

| Parameters            | months          |
|-----------------------|-----------------|
|                       | Nov  | Dec  | Jan  | Feb  | Mar  | Apr  | May  | June | July | Aug  | Sep  | Oct  |
| Air temperature (°C)  | 23 ±0.325 | 19.5 ±0.236 | 23 ±0.214 | 26 ±0.245 | 29 ±0.134 | 33 ±0.145 | 30 ±0.221 | 29.5 ±0.095 | 25.5 ±0.437 | 28 ±0.342 | 30 ±0.332 | 27 ±0.165 |
| Water temperature (°C)| 20 ±0.374 | 17 ±0.452 | 18 ±0.215 | 21 ±0.336 | 23 ±0.223 | 30 ±0.526 | 28 ±0.456 | 29 ±0.126 | 29 ±0.456 | 29 ±0.371 | 29.5 ±0.217 | 25 ±0.275 |
| pH                    | 8.8 ±0.24 | 8.1 ±0.212 | 8.7 ±0.325 | 7.4 ±0.216 | 6.8 ±0.332 | 6.6 ±0.315 | 7.3 ±0.168 | 7.2 ±0.256 | 6.6 ±0.122 | 7.4 ±0.345 | 8.3 ±0.470 | 8.7 ±0.335 |
| CO₂ mg/l              | 1.909 ±0.536 | 56.1 ±0.573 | 65.47 ±0.657 | 87.29 ±0.634 | 60.01 ±0.731 | 78.2 ±0.315 | 76.38 ±0.553 | 179.59 ±0.332 | 134.6 ±0.675 | 16.02 ±0.132 | 18.48 ±0.040 | 36.96 ±0.560 |
| DO mg/l               | 7.67 ±0.223 | 4.96 ±0.089 | 7.67 ±0.342 | 7.44 ±0.421 | 7.83 ±0.325 | 6.65 ±0.210 | 6.26 ±0.167 | 6.65 ±0.097 | 6.65 ±0.275 | 6.88 ±0.551 | 7.66 ±0.345 |
| BOD mg/l              | 2.63 ±0.035 | 1.95 ±0.057 | 3.84 ±0.076 | 2.74 ±0.015 | 0.39 ±0.041 | 0.78 ±0.063 | 0.7 ±0.076 | 0.85 ±0.035 | 0.23 ±0.134 | 1.8 ±0.087 | 4.53 ±0.162 | 3.81 ±0.112 |
| Chloride mg/l         | 16.99 ±0.216 | 13 ±0.116 | 32.09 ±0.217 | 31.38 ±0.237 | 31.24 ±0.216 | 44.87 ±0.235 | 42.6 ±0.257 | 43.26 ±0.218 | 44.02 ±0.275 | 14 ±0.120 | 14 ±0.139 | 15 ±0.431 |
| T Alkalinity mg/l     | 80.36 ±0.563 | 67.68 ±0.32 | 108.16 ±0.336 | 105.04 ±0.345 | 124.8 ±0.442 | 115.4 ±0.642 | 135.2 ±0.453 | 135.2 ±0.351 | 114.4 ±0.667 | 95.94 ±0.655 | 69.3 ±0.671 | 79.8 ±0.539 |
| Total Hard mg/l       | 77.52 ±0.661 | 91.8 ±0.546 | 82 ±0.711 | 80.2 ±0.534 | 90.66 ±0.477 | 80.6 ±0.576 | 76 ±0.635 | 92 ±0.895 | 94 ±0.932 | 86.4 ±0.655 | 84.24 ±0.563 | 69.36 ±0.736 |
| Ammonia mg/l          | 1.72 ±0.059 | 6.8 ±0.271 | 15.43 ±0.573 | 9.63 ±0.344 | 10.77 ±0.473 | 5.99 ±0.076 | 6.11 ±0.094 | 9.31 ±0.197 | 1.74 ±0.068 | 3.06 ±0.086 | 9.69 ±0.437 | 6.46 ±0.081 |
| Phosphate mg/l        | 0.08 ±0.003 | 0.07 ±0.015 | 0.16 ±0.011 | 0.09 ±0.001 | 0.1 ±0.001 | 0.37 ±0.031 | 0.64 ±0.053 | 0.62 ±0.002 | 0.76 ±0.003 | 0.04 ±0.002 | 0.22 ±0.011 | 0.4 ±0.032 |
TABLE 2. Air and water temperature and physico-chemical parameters of water at (Itahari sub-metropolitan pond recorded during November 2014 to October 2015 (Mean±S.D., N=5).

| Parameters      | Nov        | Dec        | Jan        | Feb        | Mar        | Apr        | May        | June       | July       | Aug        | Sep        | Oct        |
|-----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| Air temperature | 23 ±0.227  | 20.5 ±0.234| 18.5 ±0.439| 22 ±0.492  | 30 ±0.633  | 30 ±0.356  | 27 ±0.312  | 25.5 ±0.336| 28 ±0.215  | 29.5 ±0.423| 30 ±0.214  | 29 ±0.415  |
| (0°C)           |            |            |            |            |            |            |            |            |            |            |            |            |
| Water pH        | 7.5 ±0.231 | 8.3 ±0.175 | 7.8 ±0.114 | 8.7 ±0.211 | 8.5 ±0.253 | 7.3 ±0.231 | 8.1 ±0.223 | 7.6 ±0.098 | 8.5 ±0.347 | 7.9 ±0.216 | 8.2 ±0.310 | 7.5 ±0.128 |
| CO2 mg/l        | 9.9 ±0.452 | 6.69 ±0.225| 23.76 ±0.544| 6.02 ±0.365| 4.49 ±0.247| 16.02 ±0.365| 2.4 ±0.247 | 4.49 ±0.132| 6.07 ±0.545| 8.8 ±0.634 | 4.58 ±0.322| 3.78 ±0.163|
| DO mg/l         | 5.56 ±0.164| 7.14 ±0.344| 7.86 ±0.231| 9.71 ±0.257| 5.94 ±0.221| 3.8 ±0.321 | 3.99 ±0.211| 4.94 ±0.225| 5.82 ±0.216| 6.17 ±0.322| 6.2 ±0.304 | 6.3 ±0.313 |
| BOD mg/l        | 1.47 ±0.067| 1.67 ±0.055| 5.78 ±0.063| 2.43 ±0.052| 2.27 ±0.043| 2.39 ±0.079| 3.54 ±0.088| 3.87 ±0.097| 2.59 ±0.065| 0.75 ±0.416| 4.22 ±0.024| 0.83 ±0.045|
| Chloride mg/l   | 9 ±0.302   | 4 ±0.224   | 18.99 ±0.442| 17.99 ±0.345| 17.99 ±0.341| 21.99 ±0.433| 23.99 ±0.552| 25.99 ±0.606| 13 ±0.403  | 14 ±0.203  | 15 ±0.476  |
| T Alkalinity mg/l| 141.64 ±0.655| 128 ±0.438 | 100 ±0.677 | 151.2 ±0.757 | 82.5 ±0.486 | 110 ±0.539 | 176 ±0.875 | 108.1 ±0.459 | 101.2 ±0.443 | 99 ±0.376 | 112.2 ±0.445 | 112.2 ±0.558 |
| T hardness mg/l | 116.82 ±0.996| 63.36 ±0.765| 99.96 ±0.457| 87.12 ±0.540| 81.18 ±0.412 | 104.94 ±0.345| 102.86 ±0.431| 99 ±0.330 | 85.15 ±0.243 | 83.16 ±0.289 | 93.06 ±0.376 | 99 ±0.435 |
| Ammonia mg/l    | 13.60 ±0.197| 0.48 ±0.012| 5.60 ±0.065| 5.77 ±0.075| 5.1 ±0.046  | 10.54 ±0.098 | 3.4 ±0.023 | 13.6 ±0.210 | 13.6 ±0.215 | 10.2 ±0.324 | 8.5 ±0.087 | 11.9 ±0.994 |
| Phosphate mg/l  | 0.2 ±0.003  | 0.16 ±0.002| 0.09 ±0.001| 0.1 ±0.002  | 0.37 ±0.005 | 0.64 ±0.013 | 0.62 ±0.015 | 0.69 ±0.022 | 1.12 ±0.027 | 1.23 ±0.036 | 0.12 ±0.002 | 0.16 ±0.004 |
TABLE 3. Pearson’s correlation coefficient (r) for air temperature and physico-chemical parameters of water at the study site (average of the corresponding month values) during November 2013 to October 2015; N=12; d. f. =11.

|                          | Water temp. (ºC) | pH | Free CO₂ (mg/L) | DO (mg/L) | BOD (mg/L) | Chloride (mg/L) | Total alkal (mg/L) | Total hardn (mg/L) |
|--------------------------|------------------|----|-----------------|-----------|------------|-----------------|-------------------|-------------------|
| **Air temperature**      |                  |    |                 |           |            |                 |                   |                   |
| (0°C)                    | P cor.           | .917* | .571           | -.759*    | -.647**    | -.272          | .442              | -.103             |
|                          | Sig. (2-t)       | .001 | .052           | .004      | .023       | .393           | .150              | .046              |
| **Water temperature**    |                  |    |                 |           |            |                 |                   |                   |
| (0°C)                    | P cor.           | 1   | -.539          | -.741*    | -.747*     | -.251          | .277              | .330              |
|                          | Sig. (2-t)       | .071 | .006           | .005      | .432       | .383           | .296              | .826              |
| **pH**                   |                  |    |                 |           |            |                 |                   |                   |
|                          | P cor.           | 1   | -.513          | .828*     | .728*      | -.541          | .629**            | -.681**           |
|                          | Sig. (2-t)       | .088 | .001           | .007      | .069       | .029           | .102              |                   |
| **Free CO₂ (mg/L)**      |                  |    |                 |           |            |                 |                   |                   |
|                          | P cor.           | 1   | .647**         | -.654**   | .648**     | .688**         | .475              |                   |
|                          | Sig. (2-t)       | .023 | .064           | .023      | .013       | .119           |                   |                   |
| **DO (mg/L)**            |                  |    |                 |           |            |                 |                   |                   |
|                          | P cor.           | 1   | .058           | .091      | .211       | .301           |                   |                   |
|                          | Sig. (2-t)       | .858 | .778           | .510      | .341       |                |                   |                   |
| **BOD (mg/L)**           |                  |    |                 |           |            |                 |                   |                   |
|                          | P cor.           | 1   | .627**         | .693**    | -.643**    |                |                   |                   |
|                          | Sig. (2-t)       | .029 | .012           | .052      |            |                |                   |                   |
| **Chloride (mg/L)**      |                  |    |                 |           |            |                 |                   |                   |
|                          | P cor.           | 1   | .834*          | .001      | .675       |                |                   |                   |
|                          | Sig. (2-t)       | .001 | .735           | .346      |            |                |                   |                   |
| **Total alk. (mg/L)**    |                  |    |                 |           |            |                 |                   |                   |
|                          | P cor.           | 1   |                |           |            |                 |                   | .536              |
|                          | Sig. (2-t)       | .001 | .346           | .536      |            |                |                   |                   |
| **Total hardness (mg/L)**|                  |    |                 |           |            |                 |                   |                   |
|                          | P cor.           | 1   |                |           |            |                 |                   |                   |
|                          | Sig. (2-t)       | .001 | .536           | .917      |            |                |                   |                   |

* Significant at 1% level (P<0.01), ** significant at 5% level (P<0.05) and Values not marked denote non-significant correlation.
**TABLE 4. Seasonal variations of air temperature and physico-chemical parameters of the study site during November 2013 to October 2015. (Mean±S.D., N=4).**

| Parameters                  | Year I                      | Year II                     |
|-----------------------------|-----------------------------|----------------------------|
|                             | Winter | Summer | Rainy | Winter | Summer | Rainy | Winter | Summer | Rainy | Winter | Summer | Rainy |
| Air temperature (°C)        | 23.87±2.954                   | 30.37±1.796                 | 27.625±1.887               | 21.00±1.957                   | 28.12±2.250                 | 29.12±0.853               |
| Water temperature (°C)      | 19.00±1.825                   | 27.50±1.732                 | 28.12±2.096                | 20.12±2.780                   | 28.50±1                    | 29.75±1.258               |
| pH                          | 8.25±0.645                    | 6.97±0.330                  | 7.77±0.944                | 8.07±0.548                    | 7.87±0.507                 | 8.04±0.405                |
| CO₂ mg/l                    | 56.98±28.442                  | 101.38±60.272               | 51.96±57.060              | 14.09±7.517                   | 3.45±1.255                 | 5.80±2.209                |
| DO mg/l                     | 6.93±1.321                    | 6.847±0.680                 | 6.83±0.625                | 7.567±1.721                   | 5.01±0.906                 | 6.12±0.209                |
| BOD mg/l                    | 3.29±1.735                    | 0.68±0.202                  | 2.59±1.953                | 2.83±2.004                    | 3.017±0.806                | 2.09±1.650                |
| Chloride mg/l               | 23.36±4.805                   | 37.84±6.891                 | 21.75±14.850             | 12.49±7.228                   | 22.49±3.415                | 11.75±4.573              |
| Total alkalinity mg/l       | 90.31±19.550                  | 127.65±9.525                | 89.86±19.690             | 130.21±22.276                 | 119.15±39.920              | 106.15±7.043             |
| Total hardness mg/l         | 82.88±6.225                   | 84.81±7.773                 | 83.5±10.314              | 91.81±22.533                 | 96.995±10.826              | 90.09±7.317              |
| Ammonia mg/l                | 8.39±5.718                    | 8.04±2.379                  | 5.23±3.570               | 6.362±5.413                   | 8.16±4.735                 | 11.05±2.194             |
| Phosphate mg/l              | 0.010±0.040                   | 0.432±0.253                 | 0.355±0.307              | 0.13±0.051                    | 0.58±0.143                 | 0.65±0.599              |

**PHYSICO-CHEMICAL PARAMETERS**

**Air temperature**

The minimum air temperature was 19.5±0.236 °C in the month of December and maximum 33±0.145 °C in the month of April during the first year study period (table 1). The minimum air temperature was 18.5±0.439 °C in January and maximum 30±0.356°C was observed in April in the second year study period (table 2). The air temperature had positive and significant correlation with water temperature (r = 0.917, P<0.01), and TA (r=0.616, p<0.05) but inverse and significant correlation with pH (r = - 0.653, P<0.05), and free carbon dioxide (r=-0.759, P<0.01) and dissolved oxygen (r =-0.647, P<0.05) whereas other did not show significant correlation.

**Water temperature**

The lowest surface water temperature was recorded (17± 0.252°C) in December and maximum (30± 0.526°C) in April (table 1). Similarly, the minimum water temperature (17.5± 0.315°C)
and maximum (31± 0.365°C) was recorded in September during the second year of the study period (table 2). The water temperature fond to be positive and significant correlation with air temperature (r =0.917, P<0.01) but inverse and significant correlation with CO₂ (r =-0.741, P<0.01) and dissolved oxygen (r = -0.747, P<0.01).

**pH**

The minimum pH recorded was 6.6± 0.315 in the month of April/July and maximum was 8.8± 0.24 in November (table 1). Likewise, the minimum pH was 7.3 ± 0.231 in April and maximum 8.7± 0.211 in February in the second year (table 2). pH had positive and significant correlation with DO (r = 0.828, P<0.01) and TA (r = 0.629, P<0.05) and BOD (r = 0.728, P<0.01) but inverse and significant correlation with TH (r = -0.681, p<0.05) (table 3).

**Dissolved oxygen**

The maximum DO was 9.71± 0.257 mg/l in the end of February and the minimum 3.8 ± 0.321 mg/l in the month of April during the first year (table 1) and second year of the study period (table 2). The dissolved oxygen showed positive and significant correlation with free CO₂ (r =0.647, P<0.05) and pH (r = 0.828, P< 0.01) but inverse and significant correlation with temperature of air (r=-0.608, p <0.05) and temperature of water (r= -0.375, P < 0.01).

**Free carbon dioxide**

The maximum free CO₂ (179.59± 0.332 mg/l) was recorded in June and minimum (2.24 ± 0.247 mg/l) in March during the first year (table 1) and second year study period (table 2). Free carbon dioxide showed positive and significant correlation with chloride (r =0.648, P<0.05) but inverse and significant correlation with BOD (r=-0.654, P<0.05) and water temperature (r= -0.681, P < 0.01).

**Total alkalinity**

The maximum total alkalinity recorded was 135.2 ±0.453 mg/l in May/June and the minimum was 67.68± 0.321 mg/l in December during the first year of the study period (table 1). Similarly, in second year study period, maximum TA was 176± 0.532 mg/l in May and minimum was 82.5± 0.465 mg/l in March (table 2). The positive and significant correlation with ambient temperature (r = 0.616, P<0.05), chloride (r = 0.834, P<0.01),BOD (r = 0.693, P<0.05) and free CO₂(r = 0.688, P<0.05) was found.

**Total hardness**

The maximum total hardness was 91.8 ± 0.546 mg/l in December and the minimum was recorded 76 ± 0.635 mg/l in May during the first (table 1) and the maximum was 116.82 ± 0.463 mg/l in November and minimum was recorded 63.36 ± 0.451 mg/l in December in the second year of the study period (table 2). The inverse and significant correlation with pH (r= -0.681, P<0.05) and BOD (r= -0.643, P<0.05) were found.

**Chloride**

The maximum chloride 44.87 ± 0.235 mg/l in April and minimum 13 ± 0.116 mg/l in December were recorded during the first year (table 1) whereas the maximum 25.99 ± 0.261 mg/l in June and the minimum 4± 0.247 mg/l in December of second year were recorded during the second year of the study period (table 2). The positive and significant correlation with CO₂ (r=0.648,
More amount of chloride obtained was may be due to mixing of toilet cleaners used in Itahari sub-metropolitan toilet.

**Biological oxygen demand**

The maximum BOD was 4.53 ±0.162 mg/l in September and the minimum was 0.23 ±0.134 mg/l in July during in first year (table 1) whereas the maximum BOD was 5.78 ±0.063 mg/l in January and the minimum was 0.75 ±0.416 mg/l in August in the second year (table 2). The positive and significant correlation with pH (r = 0. 728, P<0.01) but inverse and significant correlation with CO₂ (r = -0.654, P< 0.05), TH (r = -0.643, P<0.05) and TA (r= -0.693, P<0.05) were found.

**Ammonia**

The minimum ammonia (1.72±0.059 mg/L) in November and the maximum (15.43±0.573 mg/L) in January were recorded during the first year (table 1). Similarly, the minimum ammonia (0.48±0.012 mg/L) in December and the maximum (13.6±0.215 mg/L) in July during second year were recorded (table 2).

The death of fishes caused by diseases are of highest significance in fish culture, hence to achieve healthy fish stock. One should implement programs such as fish parasitological research, control of diseases and maintenance of health relationship between the fishes and their environment. The parasite community of fishes shows considerable variation with the environmental conditions in which they live. Various physico-chemical factors such as water temperature, alkalinity, ammonia, free CO₂, DO, pH and TH have strong influence on fish health and their resistance against the disease causing agents (Welch, 1941; Snieszko, 1974; Plumb et al., 1988; Shrestha, 1994). Poor condition of physico-chemical properties of water is due to O₂ depletion, excess ammonia, excess CO₂ in water and temperature change. Delaware & Hossain et al. (2007) reported that monthly variations of the physico-chemical parameters in some 12 Beels and 210 ponds in Natore, changing in water quality parameters resulted in a stress response in the fishes, making them more susceptible to parasitic attacks and diseases, many of them being fatal.

In present study, the water temperature of study site was higher in rainy season in the first and second year (table 4). Generally water temperature is influenced by air temperature and intensity of solar radiations. Bose & Gorai (1993) reported negative correlation between water temperature and dissolved oxygen. Welch (1952) and Munawar (1970) had had observed that shallower the water body more quickly it reacts to the change in temperature.

The highest pH of study site was recorded in winter and lowest in the summer season in both years (table 4). Several workers have reported low pH during the low photosynthesis due to the formation of carbonic acid (Hannan & Yong, 1974; Cabecadas & Brogueiria, 1987; Bais
et al., 1995). However, Gautam (1990) reported highest pH in summer and lowest in rainy season. Rawat et al. (1995) reported positive correlation with total alkalinity.

The CO2 of the present study site was higher in summer in the first year but higher in winter in the second year (table 4), it may be due to high temperature, high rate of decomposition of organic matter, low volume of water etc. Michel (1969) stated that the concentration of carbon dioxide is directly correlated with the amount and nature of biological activities in water. Gautam (1990), and Pandey & Lal (1995) also found minimum carbon dioxide in winter season.

The DO of study site was recorded higher in winter in both years (table 4). Generally, the maximum DO found in winter season may be due to low temperature (Moitra & Bhattacharya, 1965). Minimum DO was found in summer season due to high temperature and higher microbial demand for oxygen in decomposition of suspended organic matter (Bhowmic & Singh, 1985). But Mc Coll (1972) reported that the relationship between water temperature and is not so significant because production and consumption of oxygen takes place simultaneously.

The BOD of study site was higher in winter in the first year and in summer in the second year (table 4). The maximum value of BOD in summer may be due to high concentration of organic matter and minimum obtained in winter may be due to low temperature and retarded microbial activities for the decomposition of organic matters. Similar observations were made by Singh (1995). Barat & Jha (2002) showed inverse correlation of BOD with DO.

Total hardness of the study site was higher in summer in both the years (table 4). It may be due to low volume and slow current of water. Similar results were obtained by Mishra et al. (1999). Minimum quantity in rainy season may be due to more dilution of water (Patralekha, 1994).

Total alkalinity was higher in summer in the first year and in winter in the second year (table 4). Singh (1990) and Mishra et al. (1998) also reported maximum pH in winter season. Barat & Jha (2002) also reported positive and significant correlation of total alkalinity with hardness.

Chloride content was found maximum in summer season in first year and the second year in present study (table 4). Chloride contents indicate the presence of organic wastes of animal origin (Thresh et al., 1949). Swarup & Singh (1979) also reported an increase in chloride during summer and minimum amount of chloride in rainy seasons was due to dilution of water by rain water.

Ammonia in the study site was recorded higher in winter season in first year and in rainy season in second year (table 4). Ammonia content of pond water is directly affected by pH. With increase in pH values, the fraction of undissociated ammonia molecule increases the fraction of dissociated ammonium ions decrease. In the rainy and winter seasons, this competition is reduced and the nitrifying bacteria could take up the ammonia even at low concentration (Yoshifomi et al., 2008).

Phosphate was recorded higher in summer season during first year and higher in rainy season in the second year in study site (table 4). It is noteworthy, phosphate increases the productivity of ponds.
On the basis of present study, the water quality of fish pond was normal except manuring period and casual addition of waste like toilet cleaners caustic potash etc. High fluctuation of chloride 4.0 - 44.87 mg/l and ammonia 0.48-13.6 mg/l was found during manuring period. Due to sudden fall in DO less than 4 mg/l; mass mortality of fishes *Labeo rohita, Cirrhina mrigala, Hypothalamichthys molitrix, Aristichthys nobilis* occurred. In September, 2015 mass mortality of same species of fishes as mentioned above occurred due to rise of ammonia after addition of human toilet wastes. Hence, drastic alterations in physico–chemical parameters adversely affect the aquatic flora and fauna (especially fish) in the study site and surrounding areas.

**ACKNOWLEDGEMENTS**

We are very thankful to University Grants Commission (UGC), Sanothimi, Bhaktapur, Nepal to provide necessary fund and facilities to carry out the research. We are thankful to the authority of SEAM-N, MMA Environmental Laboratory, Biratnagar, Nepal and ecological laboratory of NBU, West Bengal, India for providing the necessary laboratory facility for carrying out this study.

**REFERENCES**

APHA (2005) Standard Methods for Examination of Water and Waste Water, 20th Edition. Washington, USA; 1325 pp.

ARYAL, S; LACOUL, P (1996) Water quality and diversity of diatoms in Punyamati River, Nepal. *Ecoprint* 3: 45–49.

BHOWMIK, M L (1988) Limnology and productivity of some Beels and Baors of West Bengal with reference to recent development. *Environ. Ecol.* 6: 42–48.

BAIS, V S; AGRAWAL, N C; TAZEEN, A (1995) Comparative study on seasonal changes in phytoplankton community in the Sagar Lake and Military Engineering Lake (M.P.). *J. Freshwater Biol* 7: 19–25.

BOSE, S K; GORAI, A C (1993) Seasonal fluctuations of plankton in relation to physico-chemical parameters of a freshwater Tank of Dhanbad, India. *J Freshwater Biol* 5: 133–140.

COWAN, S T; STEEL, K J (1993) Manual for the identification of medical bacteria. Cambridge University Press Inc. (London), U.K.; 331 pp (3rd edition).

DOBRIYAL, A K; SINGH, H R (1989) Observation on temporal trends of phytoplankton diversity in the river Nayar of Garhal Himalaya. *J Freshwater Biol* 1: 1–6.

DOFD (2007) Country profile- Nepal 2006/2007 Fishery sub-sector. Directorate of Fisheries Development (DOFD), Department of Agriculture, Balaju, Kathmandu, Nepal; 3p.

GAUTAM, A (1990) *Ecology and Pollution of Mountain Waters*. Ashish Publishing House New Delhi.

HOSSAIN, M; KABIL, M; RAHMAN, M (2007) Water quality parameters and incidence of fish diseases in some water bodies in Natore, Bangladesh. *J Life Earth Sci* 2(2): 27–30.

LOHMAN, K; JONES, M F K; SWAR, D G; PAMPERL, M A; BRAZOS, B J (1988) Pre and post monsoon limnological characteristics of lakes in the Pokhara and Kathmandu Valleys Nepal. *Verh Internat. Verein Limnol* 23: 558–565.

MCCOLL, R H S (1972) Chemistry and trophic status of seven New Zealand Lakes. *N.Z.J. Mar Freshwater Res* 6: 399–447.

MC EACHERN, P (1994) Limnology and natural wetlands survey. In BHANDARI, B; SHRESTHA, T B; MCEACHERN, P (eds) *Safeguarding wetlands in Nepal*. IUCN, Nepal, pp 89–103.
MISHRA, A P; BORA, B K; SHARMA, M (1998) Investigations on the seasonal variation of certain physico-chemical parameters of a Beel, Assam, India. J Freshwater Biol 10: 83–87.

NIROULA, B; SINGH, K L B; THAPA, G B; PAL, J (2010) Seasonal variations in physico-chemical properties and biodiversity in Betana pond, eastern Nepal. Our Nature 8: 212–218.

ORMEROD, S J; BUCKTON, S T; BREWIN, P A; JENKINS, A; JOHNSON, R C; JUTTNER, U; SUREN, A (1996)iodiversity, chemistry and structure in streams of the Nepalese himalaya. In CHALISE, S R; KHANAL, N R (eds) Proc. Inter. Confer. Ecohydrol. High Moun. Kathmandu, Nepal; pp 1197–1200.

PANDEY, K K; LAL, M S (1995) Limnological studies of Garhwal himalayan hill stream Khandagad: seasonal fluctuation in abiotic profile. J Freshwater Biol 7: 7–11.

PATRALEKH, L N (1994) Comparative account of physico-chemical properties of three freshwater ecosystems. J Freshwater Biol 6: 115–119.

RAWAT, M S; JIJAYAL, C P; SHARMA, R C (1995) Morphometry and physico-chemical profile of high altitude lake Deoria Tal of Garwal himalaya. J Freshwater Biol 7: 1–6.

REID, G K (1961) Ecology of inland water and streams. Reinhold Publication Corporation, New York, U.S.A; 375 pp.

SCHAPERCLAUS, W (1991) Fish diseases, vol-I. Oxonian Press Pvt. Ltd., New Delhi, Culcutta, India; pp 46–71 (5th edition).

SHRESTHA, J (1994) Fishes, fishing implements and methods of Nepal. In MAJUPURIA, T C (ed) Pub. Smt. Gupta, M.D. Lalitpur Colony, Lashkar, India.

SHRESTHA, J (2001) Taxonomic revision of fishes of Nepal. In JHA, P K; BARAL, S R; KARMACHARYA, S B; LEKHAL, H D; LACOUL, P; BANIYA, C B (eds) Environment and agriculture: biodiversity, agriculture and pollution in south Asia. Ecological Society (ECOS), Kathmandu, Nepal; pp 171–180.

SHRESTHA, T K (2008) Fish diversity of Nepal and potentiality of indigenous fishes for future development of aquaculture. Workshop on indigenous fish stock and livelihood. Organised by NARC, Khumaltar, Lalitpur, Nepal; pp 1–20.

SHRESTHA, M K; MISHRA, R N (2014) Fish production systems in Nepal. National Fisheries and Aquaculture Program. Annual innovation lab council partners workshop, March 10-12, 2014; Lazimpat, Kathmandu, Nepal.

SINGH, R K; SINGH, S P (1995) Phyco-chemical conditions of the river Sone at Dalmianagar (Bihar). J Freshwater Biol 7: 93–98.

SINGH, H P (1990) Distribution and seasonal fluctuation of certain physico-chemical features in the Brahmaputra river. J Assam Sci Soc 32: 64–69.

SWARUP, K; SINGH, S R (1979) Limnological studies on Suraha lake (Ballia). J Inland Fish Soc India 11: 22–23.

THRESH, J C; BEALE, J F; SUCKLING, E V (1949) The examination of water and water supplies. TAYLOR, E W (ed). Churchill Ltd., London, U. K.

TRIVEDI, R K; GOEL, P K (1984) Chemical and biological methods for water pollution studies. Environmental Publications, Karad, India; 215 pp.

YOSHIFUMI, A; TATSUNORI, N; REIJI, T; KIYOSHI, Y; TATSUAK, T (2008) Seasonal changes in abundance of ammonium-oxidizing bacteria and their nitrification in sand of Eelgrass zone. Microbes. Environ 24, 121–127.