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Research Article

Evaluation of physico-chemical characters of Singhia and Budhi rivers in Sunsari and Morang Industrial corridor, Nepal

[1]Ganesh Bahadur Thapa and [2]Joydeb Pal

[1]Department of Zoology, Central Campus of Technology, Tribhuwan University, Dharan (Hattisar), Sunsari, Nepal.
[2]Department of Zoology, University of North Bengal, Siliguri-734013, West Bengal, India.
*Corresponding author: *gthapast@yahoo.com*

Abstract

Singhia and Budhi rivers lying along side of the industrial corridor in Sunsari and Morang districts Nepal. Both perennial rivers fed with various effluents from around 100 industries. Toilet wastes, safetytank seepage, hospitals and clinic wastes, insecticides, herbicides washed in agriculture fields from Biratnagar sub-metropolitain, Itahari municipality and adjoining VDCs drained into these rivers and sand mining increased turbidity. Present study revealed that the maximum and minimum variations and correlation between different physicochemical variances. It was observed as per the addition of wastes, seasonal and unusual climatic changes. The fluctuation of CO_2 was 80.08±1.352mg/l in September and 14.56±0.359mg/l in March of first year. Ammonia 15.32±0.782 mg/l in June and 0.260±0.075 mg/l in December. Turbidity was highest in September1078±2.359and lowest 48.01±1.435mg/l in January and highly fluctuated 264.08±143.39 (Singhia) and 635.03±373.389 NTU (Budhi) in rainy season. TA and TH were more fluctuated in summer in the second year in Budhi river than the Singhia. High Chloride 15.10±0.093 mg/l in November and 4.05±0.069 mg/l in December was observed in the second year in Singhia. Chloride and ammonia were slightly fluctuated throughout the year. The values were found within the permissible limit for fish farming as per WHO standards.

Keywords: Singhia, Budhi, river, physicochemical , seasonal , fish farming.

Introduction

Water Pollution is mainly a problem due to explosion of population, rapid indiscriminate urbanization and industrialization. The large scale urban growth has increased domestic effluents while industrial development manifested either due to setting up of new industries or expansion of the existing industrial establishments resulting of copious volume of industrial effluents. Human activity and cattle grazing also add to the river pollution. Once the contaminants enter the water source, it is difficult and costly to remove them. Unplanned and injudicious disposal of municipal waste are causing pollution of water bodies have put tremendous pressure on water resources and their quality. So, it requires regular monitoring and evaluating water quality. Singhia and Budhi rivers of Morang and Sunsari, Nepal fed wastes from around 100 industries, Sub-metropolitan, Municipal and hospitals. Furthermore, mixing of human toilet wastes, agrochemicals from agriculture fields directly and indirectly, cleaning utensils and mining of sand from the river bed deteriorating the river water quality.

The physicochemical parameters (PCP) of a water body change due to seasonal change, diurnal changes and pollutants. These bring significant seasonal and diurnal change in abundance of aquatic organisms. Among the PCP air temperature, water temperature, transparency, pH, dissolved oxygen, free carbon dioxide, alkalinity, hardness, chloride and BOD mainly determine the hydrological condition of water body (Reid, 1961). The objectives of the study are to suppose the present water quality of these rivers, through analysis of some selected parameters and to compare the results with the WHO standard. In natural aquatic system, concentration of various physicochemical parameters increase as a result of rapid growth of population, increased urbanization, expansion of industrial activities, exploitation of natural resources, extension of irrigation and lack of environmental regulations (Mehedi *et al*., 1999).

Materials and Methods

Two sites were selected along the Industrial corridors of Sunsari and Morang districts. The Singhia river, Morang near upstream at Hatkhola bridge located within latitude 26^0 27’34.10” N , longitude 87^0 17’ 30.37”E and altitude 238fts (Site1) and Budhi river, Sunsari near upstream at Budhi bridge Duhabi located within latitude 26^0 33’ 33.43”N , longitude 87^0 16’ 46.53”E and altitude 293fts(Site 2). Parameters taken were as follows: Air temperature, water temperature, pH, turbidity, total dissolved solids, dissolved carbon dioxide, ammonia, nitrate, dissolved oxygen, biological oxygen demand, chloride, total alkalinity, total hardness and phosphate following Trivedi and Goel (1984) and APHA (2005). During the two years study period some PCP were taken on the spot e.g. DO, pH, temperature and CO_2.Other parameters were analyzed in the laboratory by carrying water samples in closed bottles. Sampling was done at 8.00. - 11.00A.M. at the last week of each month. Whole year was divided into three seasons – Winter season (Nov.- Feb.), Summer season (March-June) and Rainy season (July-Oct.).Monthly data of different parameters were pooled into seasonal data. Infected fishes from these sites were also collected. Standard deviation, correlation coefficient were calculated by using Microsoft excel statistical function of computer software. The correlation coefficient between different variables is calculated and their significance difference was tested using SPSS.

Results and Discussion

Physico-chemical parameters of Site 1 and 2

Singhia river (Site1)

The minimum air temperature was 19.25 ±0.359^{0}C in the month of February and maximum 31.13±0.521 °C in the month of September during the first year study period (Table 1). The minimum 19±0.452 °C in the month of January and maximum air temperature was 32.5 ±0.497 °C in the month of March during the second year (Table 2).

The air temperature had positive and significant correlation with water temperature ($r = 0.974, P<0.01$), turbidity ($r=0.626, p<0.05$), TA ($r= 0.996, P<0.01$) and ammonia ($r = 0.648,p<0.05$) but inverse and significant correlation with pH ($r = - 0.656, P<0.05$), and DO ($r=-0.626, p<0.05$). Positive correlation of water temperature with TDS ($r=0.594, p<0.05$) , with ammonia ($r=0.738,p<0.01$) , Turbidity with nitrate ($r=0.581,p<0.05$) , with Phosphate($r=0.675,p<0.05$) , conductivity with chloride ($r= 0.718, P<0.05$), with TA ($r=0.662,p<0.05$), TA with CO_2($r=0.657,p<0.05$), phosphate with CO_2($r=0.670,p<0.05$) ,BOD with TA ($r=0.729,p<0.01$) ,TH with chloride ($r=0.712,p<0.01$), chloride with ammonia ($r=0.730,p<0.01$), with phosphate($r=0.697,p<0.05$),TDS with nitrate ($r=0.597,p<0.05$) ,phosphate with chloride($r=0.656,p<0.05$) and with ammonia ($r=0.697,p<0.05$). Other shows insignificant correlation in different sites.

Budhi river (Site 2)

Budhi river had positive and significant correlation of the air temperature with water temperature ($r = 0.963, P<0.01$) and ammonia ($r=0.615, p<0.05$), pH with CO_2($r=0.700, p<0.05$), TDS with phosphate ($r=0.718, P<0.01$), conductivity with chloride ($r=0.876, P<0.01$), phosphate with turbidity ($r=0.585, P<0.05$) had observed. Inverse and significant correlation of water temperature with DO ($r = - 0.869, P<0.01$), air temperature with DO ($r =- 0.972, P<0.01$), Ammonia with DO ($r =- 0.769, P<0.01$), TDS with DO ($r = - 0.684, P<0.05$) and pH with nitrate ($r=-.946, p<0.01$) and others show insignificant correlation.

The pH of water is naturally acidic because the atmospheric CO_2 combines with water, forming a weak carbonic acid (H_2CO_3). There are minerals in soil that can dissolve in water to create acidity and alkalinity as well. River CO_2 concentrations and pH, are affected by respiration and photosynthesis as a result, pH varies throughout the day.

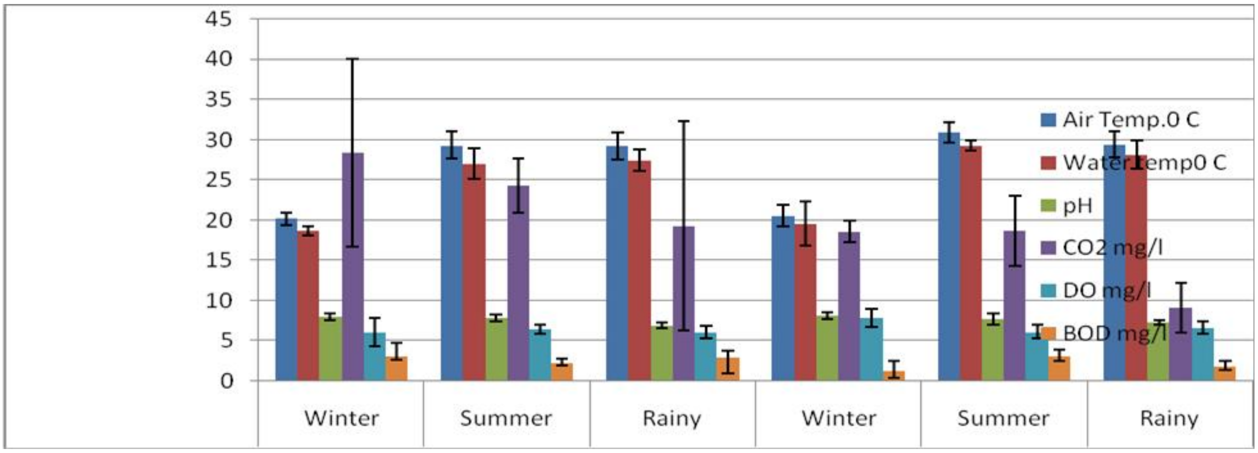
Singh *et al.* (1982) studied seasonal and diurnal changes in physico - chemical features of the river Brahmaputra at Guwahati and found high free carbon

Table 1.Shows seasonal variations of air temperature and physico-chemical parameters of Site 1 (Singhia river, Biratnagar) during Nov.2008- Oct. 2010. **(Mean±S.D., N=4).**

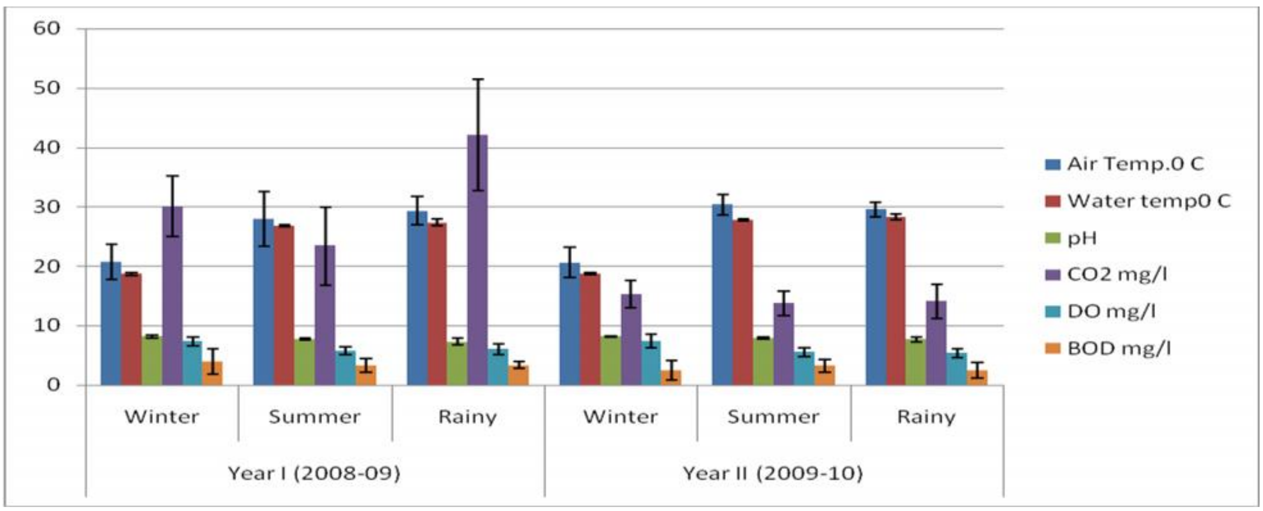
Parameters of Site 1	Year I (2008-09)			Year II (2009-10)		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Air Temp. ^{0}C	20.19±0.758	29.30±1.692	29.22±1.719	20.57±1.292	30.92±1.303	29.42±1.600
Water temp ^{0} C	18.65±0.608	27.05±1.853	27.47±1.315	19.56±2.734	29.26±0.649	28.18±1.747
pH	8.002±0.396	7.83±0.464	6.87±0.354	8.17±0.408	7.71±0.657	7.26±0.311
Turbidity NTU	45.64±29.201	138.32±94.434	206.51±148.95	50.79±4.790	133.68±99.836	264.08±143.39
TDS mg/l	284.56± 51.357	298.79± 57.78	206.15±148.955	184.57±1.749	298.07±55.535	260.59±101.99
Conductance	642.25± 81.459	490± 39.991	399±137.377	478.07±209.438	547±43.027	398.67±187.146
CO_2 mg/l	28.38±11.725	24.29± 3.341	19.30±13.001	18.60±1.404	18.70±4.338	9.11±3.070
DO mg/l	6.095±1.712	6.45± 0.608	6.102±0.820	7.84±1.169	6.11±0.827	6.62±0.760
BOD mg/l	3.05± 0.365	2.23± 0.231	2.945±2.030	1.302±0.844	3.13±0.605	1.81±0.364
Chloride mg/l	4.94 ±1.710	9.05± 1.443	8.05±1.447	8.29±4.817	10.22±0.565	11.49±2.034
T.alkalinity mg/l	193.71±61.759	166.91±12.849	153.15±39.999	168.97±4.206	181.37±16.726	162.12±19.247
T.hardness mg/l	153.16±21.617	158.49±5.078	132.99±32.569	148.20±42.171	135.50±14.034	143.83±24.799
Ammonia mg/l	4.045± 1.908	6.48±2.2	6.472±0.383	3.91±3.590	8.97±1.605	8.93±2.363
Nitrate mg/l	0.140±0.127	0.099±0.086	0.230±0.174	0.0009±0.0006	0.028±0.026	0.45±0.442
Phosphate mg/l	0.257±0.235	0.535±0.333	0.115±0.108	0.152±0.132	0.407±0.342	0.657±0.161

Table 2.Shows seasonal variations of air temperature and physico-chemical parameters of Site 2 (Budhi river, Sunsari) during Nov.2008- Oct. 2010. **(Mean±S.D., N=4).**

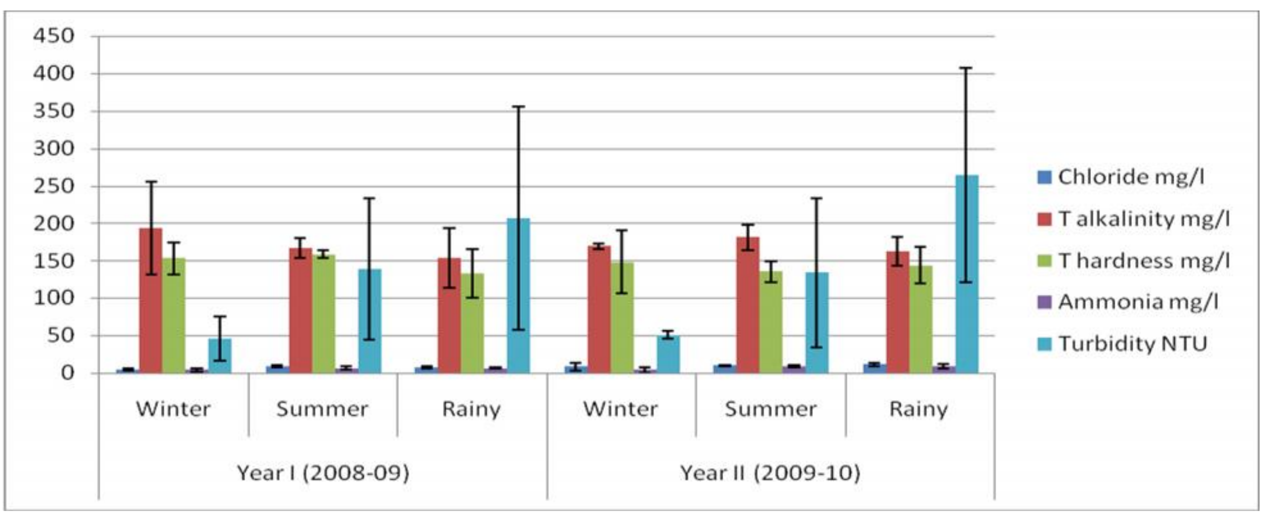
Parameters of Site 2	Year I (2008-09)			Year II (2009-10)		
	Winter	Summer	Rainy	Winter	Summer	Rainy
Air Temp. ^{0}C	20.72±3.012	27.95±4.64	29.33±2.34	20.63±2.61	30.35±1.693	29.58±1.222
Water temp ^{0} C	18.68±2.293	26.84±2.21	27.35±2.51	18.8±1.986	27.80±0.921	28.29±1.217
pH	8.22±0.253	7.69±0.182	7.28±0.578	8.16±0.147	7.90±0.156	7.71±0.422
Turbidity NTU	66.67±27.58	110.8±30.93	556.28±449.93	110.32±72.83	113.06±1.73	635.03±373.389
TDS mg/l	241.35±12.16	333.33± 90.46	271.60±19.10	172.39±51.36	312.58±123.7	302.88±97.924
Conductance	861± 52.121	739.25± 123.09	668±97.594	677.25±184.547	769±129.823	659.25±148.077
CO_2 mg/l	30.14± 5.117	23.43± 6.581	42.07± 9.37	15.31±2.234	13.762±2.109	14.12±2.894
DO mg/l	7.36±0.752	5.76± 0.635	6.01±0.831	7.42±1.078	5.51±0.728	5.39±0.711
BOD mg/l	3.967± 2.176	3.35± 1.140	3.36±0.605	2.525±1.644	3.24±1.027	2.43±1.312
Chloride mg/l	6.157 ±2.485	6.22± 1.107	9.49±0.717	7.36±3.901	9.68±2.418	8.94±3.364
T.alkalini mg/l	185.08±41.457	207.98±15.506	163.72±50.928	209.19±20.548	211.29±12.245	192.71±44.016
T hardness mg/l	161.05±14.563	177.62±10.621	123.82±31.642	145.60±43.351	165.03±27.130	147.36±27.870
Ammonia mg/l	4.83± 1.353	7.59±1.93	7.41±1.416	3.442±3.084	6.57±5.834	10.61±2.844
Nitrate mg/l	0.026±0.022	0.034±0.030	0.052±0.038	0.052±0.048	0.046±0.044	0.547±0.527
Phosphate mg/l	0.09±0.063	0.422±0.234	0.385±0.247	0.255±0.239	0.377±0.203	0.445±0.440



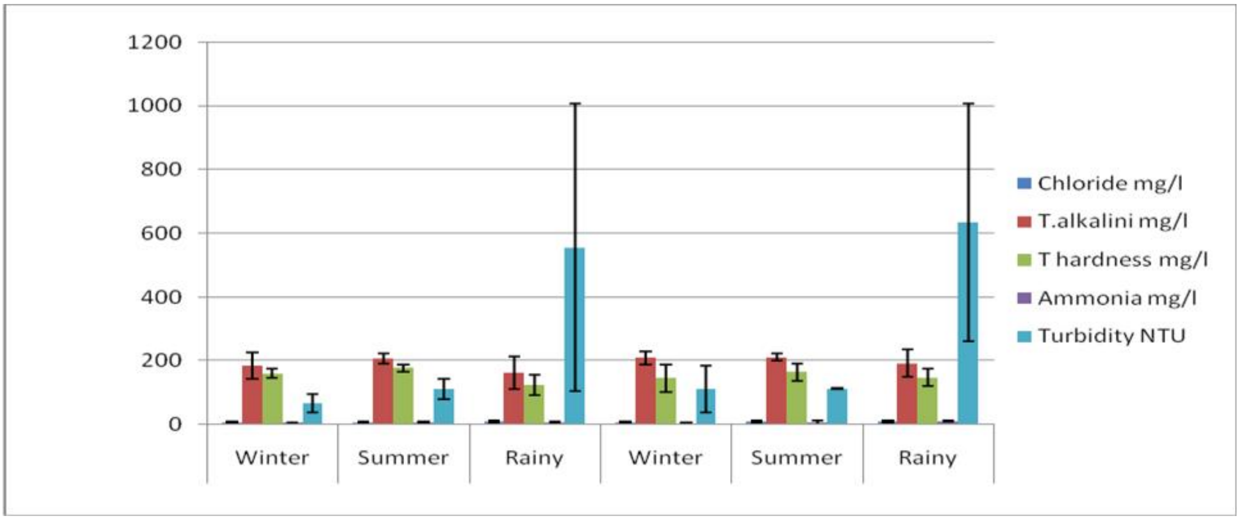
S_1a . Seasonal fluctuation of physicochemical parameters of Singhia river



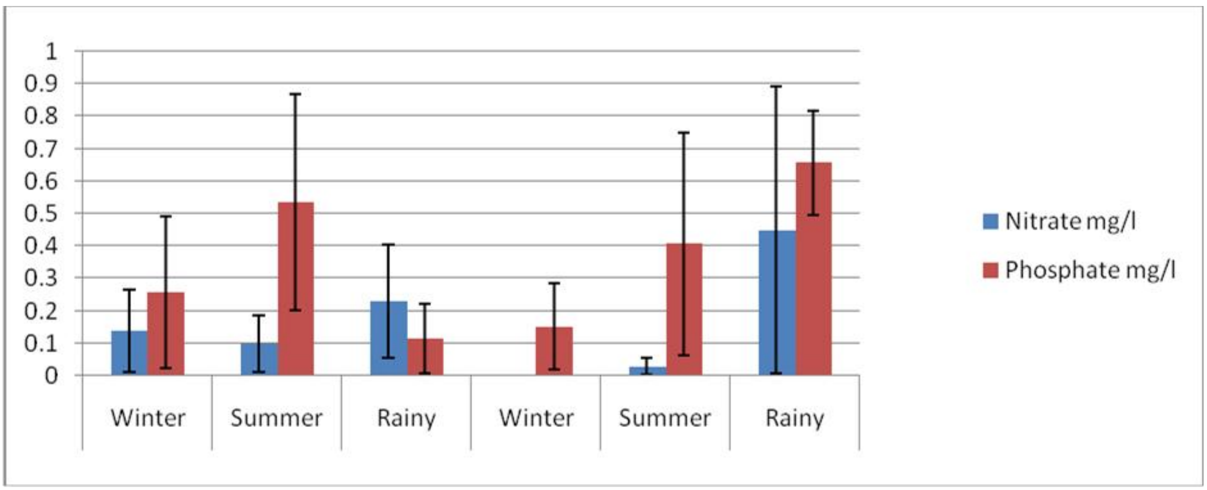
S_2a. Seasonal fluctuation of physicochemical parameters of Budhi river



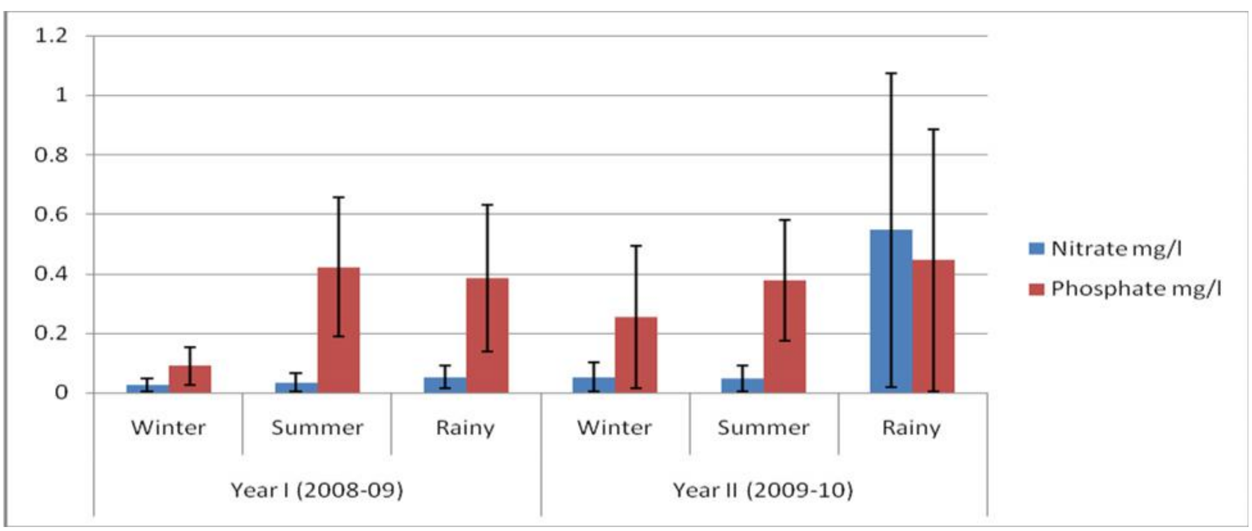
S_1b. Seasonal fluctuation of PCP in Singhia river (Site 1)



S_2b. Seasonal fluctuation of PCP in Budhi river (site 2)



S_1c. Seasonal fluctuation of nitrate and phosphate in Singhia river



S_2c. Seasonal fluctuation of nitrate and phosphate in Budhi river(2) dioxide concentration to be related to low concentration of oxygen and vice-versa. Bhowmick and Singh (1985) found that the low values of dissolved oxygen in the summer season mainly due to high temperature and microbial demand for oxygen in decomposition of suspended and dissolved organic matters.

Niraula *et al*. (2010) has 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 but water depth, temperature, ammonia and carbon dioxide were found to be higher in rainy season. 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) were observed in Betana wetland, Eastern Nepal.

Chhetry and Pal (2011) has studied the physico-chemical parameters of water of Koshi river at Kushaha area , Nepal and revealed the similar results. Bhatt and Khanal (2011) reported that the increase in pH appear to be associated with increasing use of alkaline detergents in residential areas. The rate of photosynthesis was greater in the early hours of the day light and decreased in the afternoon.

Total hardness of all the selected sites of Cauvery River showed maximum in summer due to reduced inflow and evaporation and minimum in monsoon was due to increasing inflow and dilution. Increasing trend was observed at all the sites with the range of 142.5 to170.9mg/l. Total hardness found to have significant positive correlation with pH, calcium, potassium and DO and had negative correlation with turbidity, EC, alkalinity, sulphate, phosphate, BOD and COD (Venkatasharaju *et al.*, 2010). The parasite community of fishes shows considerable variation with the environmental conditions in which they live. The water temperature, alkalinity, ammonia, free carbon dioxide, dissolved oxygen (DO), pH and total hardness have strong influence on fish health and their resistance against the disease causing agents (Shrestha,1994; Hossain,1990). Poor condition of physicochemical properties of water is O_2 depletion, excess ammonia, excess CO_2 in water and temperature change. Hossain *et al*. (2007) reported that 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 were fatal.

Ammonia is a nitrogenous waste released by aquatic animals into the aquatic environment. It is a primary byproduct of protein metabolism and excreted directly from the fish gill into the water which is toxic to aquatic life and toxicity is affected by water pH. Ammonia-nitrogen (NH_3-N) has a more toxic form at high pH and a less toxic form at low pH, un-ionized ammonia (NH_3) and ionized ammonia (NH_4^+), respectively. In addition, ammonia toxicity increases as temperature rises.

Fish digest the protein in their feed and excrete ammonia through their gills and in their faeces. Ammonia also enters the water from bacterial decomposition of organic matter such as uneaten feed or dead algae and aquatic plants. The proportion of TAN in the toxic form (NH_3) increases as the temperature and pH of the water increase. For every pH increase of one unit, the amount of toxic unionized ammonia increases about 10 times (Wurts, 2003).

Uptake of ammonia by plankton algae is important to reduce the amount of ammonia coming in contact with fish. Lower water temperatures slow down aerobic bacterial activity, thus slowing the nitrification process whereby ammonia is converted to harmless nitrate. Rotting of algae can also lead to very high ammonia concentrations but the low pH associated with the disappearance of the algae reduces the proportion of toxic un-ionized ammonia. Dangerous short-term levels of toxic un-ionized ammonia may kill fishes.

The cycling of phosphorus within lakes and river is dynamic and complex, involving adsorption and precipitation reactions, interchange with sediments and uptake by aquatic biota (Borberg and Persson, 1988).

The air temperature of Site 1 was higher in summer in the first and second year study period and the lowest temperature was recorded in winter in both years (Table 1).The air temperature of Site 2 was higher in rainy in the first year but in summer season in the second year. The lowest temperature was recorded in winter in the second year (Table 2). Gradual increase in air temperature was noticed during rainy seasons (S_1, S_2). The water temperature of Site 1 was higher in rainy in the first year and in summer in the second year (Table 1).The water temperature of Site 2 was higher in rainy season in the first and second year (Table 2). Generally water temperature is influenced by air temperature and intensity of solar radiations. Bose and Gorai (1993) reported negative correlation between water temperature and dissolved oxygen .Welch (1952) and Munawar (1970) had observed that shallower the water body more quickly it reacts to the change in temperature.

Turbidity in water is caused by suspended and colloidal matter such as clay, silts, finely divided organic and inorganic matter, plankton and other microscopic organisms. Turbidity diffuses sunlight and slows photosynthesis. Plants begin to die, reducing the amount of dissolved oxygen and increasing the acidity by producing carbonic acid and lowers the pH level. Both of these effects harm aquatic animals. Turbidity raises water temperature because the suspended particles absorb the sun's heat. Warmer water holds less oxygen, thus increasing the effects of reduced photosynthesis. Some eggs and larval stages of aquatic animals may not adjust well to the warmer water. Highly turbid water can clog the gills of fish, stunt their growth and decrease their resistance to diseases.

The organic materials that may cause turbidity can also serve as breeding grounds for pathogenic bacteria. When drinking water reservoirs are turbid, the water treatment plant usually filters the water before disinfecting it. Industrial processes and food processing, require clear water. Turbid water can clog machines and interfere with producing food and beverages. The study revealed that turbidity was higher in rainy and lower in summer seasons in both sites. There was high fluctuation of turbidity during rainy season due to flooding (Graph S_1b and S_2c).

The highest pH was recorded in winter in the first year and the second year in Site 1(Table 1). The highest pH 8.22mg/l of Site 2 was recorded in winter and lowest in the rainy season in both years (Table 2). It was due to lowering of water temperature. Several workers have reported low pH during the low photosynthesis due to the formation of carbonic acid (Bais *et al*.,1995). However, Gautam (1990) reported highest pH in summer and lowest in rainy season. Rawat *et al.* (1995) reported positive correlation of pH with total alkalinity.

Conductivity is a good and rapid method to measure the total dissolved ions and is directly related to total solids. Higher the value of dissolved solids, greater the amount of ions in water (Bhatt *et al*.,1999). Higher value of conductance was in winter in the first year and summer in the second year in both sites (Table 1, Table 2). It was flooding condition in summer mainly due to climatic changes.

The CO_2 of Site 1 was higher in winter in first year and in summer in the second year (Table 1). The CO_2 of Site 2 was higher in rainy in the first year but higher in winter in the second year (Table 2). 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 and Lal (1995) also found minimum carbon dioxide in winter season.

DO of Site1 was higher in summer in the first year and in winter in the second year (Table 1). The DO of Site 2 was recorded higher in winter in both years (Table 2). Generally, the maximum DO found in winter season may be due to low temperature (Moitra and Bhattacharya, 1965).Minimum DO was found in Summer due to high temperature and higher microbial demand for oxygen in decomposition of suspended organic matter (Bhowmic and Singh,1985). But McColl (1972) reported that the relationship between water temperature and oxygen is not so significant because production and consumption of oxygen takes place simultaneously.

BOD of both Budhi and Singhia were higher in winter during first year and in summer in the second year (Table 1and Table 2). 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 and Jha (2002) showed inverse correlation of BOD with DO.

Chloride content of Site1 was recorded maximum in summer in the first year and in rainy in the second year (Table 1) whereas it was maximum in rainy in first year and in summer in the second year in Site 2 (Table 2).Chloride contents indicates the presence of organic wastes of animal origin (Thresh *et al*., 1949).Swarup and 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.

Total alkalinity of Site 1 was higher in winter in the first year but higher in summer in the second year it was may be due to climate changes (Table1). It was higher in summer in the first and second year in site 2 (Table 2). Singh (1990) and Mishra *et al. (*1998) also reported maximum pH in winter. Barat and Jha (2002) also reported positive and significant correlation of total alkalinity with hardness.

Total hardness of Site1 was highest in summer in the first year but in winter in the second year but in Site 2 had higher in summer in both the years (Table 1, Table 2). It is 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).

Ammonia of Site 1 was recorded higher in summer in both the first and second year (Table 1) whereas ammonia in Site 2 was recorded higher in summer in the first year and in rainy in the second year (Table 2). Ammonia content of water body is directly affected by pH. With increase in pH values, the fraction of undissociated ammonia molecule increases the fraction of dissociated ammonium ions decreases. 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). When chicken droppings were added in Baidya fish pond, ammonia was raised upto18.7 mg/l which led to mass mortality of fish (Pangasius) during August,2010.(Thapa and Pal, 2012).

Phosphate was recorded higher in summer during first year and in rainy season in the second year at both Site1 (Table 1) and Site 2 (Table 2).Phosphate increases the productivity of water bodies.

Conclusion

The water quality of rivers Budhi and Singhia were moderately polluted except period of addition of toilet wastes, detergents, untreated industrial effluents, hospital wastes etc. The value of different physico-chemial parameters were found within the permissible limit as per WHO standards. The analysis revealed that these rivers water were not fit for human consumption and recreation, but still can be used for irrigation and fish culture. The drastic fluctuations in physico–chemical properties adversely affect the aquatic flora and fauna (especially fish) and other organisms in surrounding areas.

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