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### PHYSICO-CHEMICAL PARAMETERS IN TINAU RIVER WATER IN RUPANDEHI DISTRICT, NEPAL

Pandey B. and Devkota A.

Central Department of Botany, Tribhuvan University, Kathmandu

Corresponding Author's Email: [devkotaa@gmail.com](mailto:devkotaa@gmail.com)

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**Abstract:** We present an extensive investigation of physico-chemical parameters of water samples of Tinau River at Butwal. Water samples under investigations were collected from Jhomsa, Dobhan Chidiya Khola and Butwal Tinau sampling station during pre monsoon (April-May), monsoon (July-August) and post monsoon (October-November) seasons in the year 2012. The observed values of different physico-chemical parameters like pH, temperature, turbidity, total hardness (TH) Chloride, total dissolved solids (TDS), total alkalinity (TA), dissolved oxygen (DO), total nitrogen, total phosphorus, electrical conductivity of samples were compared with standard values recommended by world health organization (WHO). The result indicated the various ranges with temperature 14.05-30.95°C, transparency 26.2 to 119.65 cm, TDS ranged from 163.8 to 265.7 mg/L, turbidity from 8.81 to 9.72 NTU, electrical conductivity varied from 91 to 94.5  $\mu$ s/cm, pH from 7.45-7.77, alkalinity from 29.55 to 33.95 mg/L, total hardness from 113.5 to 172.2 mg/L, DO 6.81 to 8.23 mg/L, chloride value ranged from 7.33 to 8.24 mg/L and total nitrogen from 0.629 to 0.76, total phosphorus ranged from 0.76 to 1.13 mg/L. All the physicochemical parameters are within the standard for drinking water except turbidity and pH (Butwal station) and raw water source for potable abstraction.

**Key words:** Physiochemical parameters; Seasonal variation, Tinau River; Water quality.

**Postal Address:** Central Department Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal, Tel No. 977 14331322

### INTRODUCTION

Water resources are under pressure and are in danger because of potential pollution and contamination due to rapid industrialization, increasing population pressure, urbanization, modern agricultural activities and other anthropogenic activities (Agrawal *et al.* 2006, Singh *et al.* 2007). Large watersheds are often intensively studied to characterize surface water quality impact on human health and/or ecosystem health impairment that may be associated with various land use practices or point and non-point sources of contamination. Chemical, physical and biological variables are generally included, although river and streams represent only a small portion of landscape, their state is indicative of the condition of the whole watershed. Rivers, like blood samples from human, are indicative of the health of the

landscape (Karr 1999). Nepal is naturally bestowed with ample water resources. The Government of Nepal has supplied drinking water to about 67% of total population. Other inhabitants have to depend on other sources such as spring, stream and tube well for drinking and house hold uses. The rural people used the most convenient sources of the water in their areas irrespective of quality due to lack of pipe water (Pradhan *et al.* 1998). Butwal is a historical city situated on the bank of the Tinau River where scientist reported the jaw of Ramapithecus. The distribution of access of water through 70% from dip tube well and 30% by surface water from Tinau river daily 1 Crore 80 Lakhs liters of water is supplied to town with simple treatment some months it is reduced due to large impurities." Most of the area is covered with steep land and forest, 10% area of the bank

of river is cover by agriculture land and 3% is cover densely populated Butwal city (Malla, 2009). The present study will identify impacts on river quality regarding physico-chemical characteristics due to the intervention of mankind on sources that will be helpful for planners and user groups to maintain standard water quality by proper management and conservation of the reservoir and its catchments.

## EXPERIMENTAL

The study was carried out in Tinau River. Water samples were collected from four different locations of river; Jhumsa (27°43'03.72"N to 83°27'52.56" E; 497 m alt.), Dobhan (27°44'42.24" N to 83°27'40.44" E, 275 m alt), Chidiya Khola (27°43'16.13" N to 83°28'11.18" E, 266 m alt.) and Butwal Tinau (27° 43'03.72" N to 83°27'52.56" E, 204 m alt.) on seasonal basis. To determine the water quality and limnological parameters, water samples were collected during winter (15<sup>th</sup> December 2011), pre-monsoon (12<sup>th</sup> April 2012) and mid-monsoon (10<sup>th</sup> August 2012). A triplicate water samples from each sampling sites were collected in standardized PET (polyethylene terephthalate) bottles, which were thermo stated bottles. The PET bottles of 1.5 liter capacities and 0.5 liter capacity with stoppers were used for sample collection. The bottles were washed thoroughly with 2% nitric acid and subsequently rinsed with distilled water. Before collecting the water samples, all bottles were rinsed with sample water 2-3 times. All the sampled bottles were made watertight by air tightening it inside water. Precaution has been taken to remove any air bubble present. Each container was clearly marked with the name and date of sampling. All the samples were preserved at 4°C till analysis. The water temperature of each site was measured with mercury thermometer, transparency was measured by Secchi disc method and pH and conductivity were determined by pH meter (692 p<sup>H</sup>/ion meter) and Conductivity meter (inoLab Cond Level L. WTW) respectively. The other physico-chemical parameters such as total alkalinity, total hardness, dissolved oxygen and microbiological analysis were carried out in the Sai Global College, laboratory, Bhairahawa for the analysis of different parameters. Analysis of phosphorous

and total nitrogen was carried out in the laboratory of Water Engineering and Training Center, Kathmandu. All the samples were kept in refrigerator at 4°C in the laboratory and before analysis samples were allowed to gain normal water temperature.

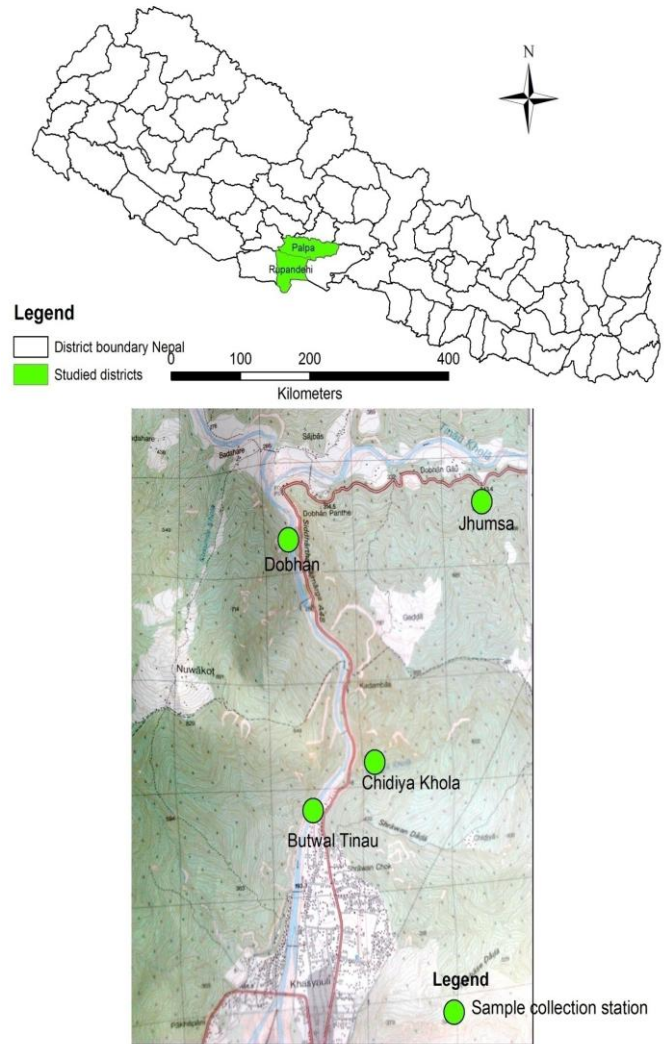


Figure 1. Location map of study area

## RESULTS AND DISCUSSION

### Physicochemical Characteristics of Water

The temporal (seasonal) and spatial (station wise) variation in physio-chemical characteristics with of Tinau River water and its tributes of their four sites have been summarized in Tables (1-3).



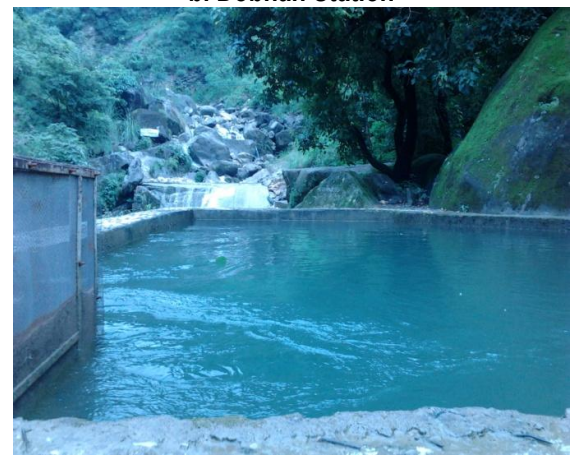
Figure 2. Laboratory work (Sai Global College)



a. Jhomsa station



b. Dobhan Station



c. Chidiya Khola Station



d. Butwal Tinau Station

Figure 3. Photographs of Sampling Locations (Drainage)



a. Terrace Cultivation



b. Solid Wastes on River sides



c. River bed extraction in upstream

Figure 4. Activities on River bed

**Temperature:** Measurement of temperature is considered as a very important factor in stream ecology (Hynes, 1979). In the present study the average value of water temperature in Tinau River varied from  $12 \pm 3.33^\circ\text{C}$  to  $30.3 \pm 2.26^\circ\text{C}$ , the lowest value in winter at Jhomsa sites *i.e.*  $10.6^\circ\text{C}$  and the highest value at Butwal Tinau *i.e.*  $33^\circ\text{C}$  during rainy season (Tables 1-3). During mid monsoon this fluctuation in water temperature was found to be related with corresponding changes in atmospheric temperature (Kundangar *et al.*, 1996).

This result is supported by the finding of Singh, 2014 in Gomti River. The result is similar to the result of Paudyal (2001) in Shivapuri reservoir. The average temperature of water in all sites was found within the EC standards (*i.e.*  $12-25^\circ\text{C}$ ) set for the surface water used for potable abstractions except in monsoon (Table 4). The average temperature of Tinau river water seems to increasing than that was recorded by Sharma *et al.*, (2003).

**Transparency:** Transparency of water is the ability of light to pass through the water so that objects situated beyond can be seen clearly. In the present study the average value of transparency at different sites ranged from 26.2 to 119.65 cm (Tables 1-3). Maximum value of transparency was recorded (109.8 to 132.2 cm) in all sites during winter and the lowest value (5 to 55.8 cm) during mid monsoon (Tables 2-3). Higher value of transparency in winter was also recorded by Bhatt *et al.* (1999) in Taudaha Lake. The gradual declination of transparency in recent years reveals higher human activities and agricultural run-off. The river water remains comparatively clear during winter, thereafter the transparency increased steadily until it attained the maximum value during pre-monsoon. The lower value of transparency during mid monsoon season was due to the entry of silt during heavy rainfall from the adjoining fields and nearby hills sides. The average value of transparency was highest in Jhomsa during winter and lowest in Butwal Tinau during mid monsoon. The value of transparency was highest in Butwal Tinau as it might be due to Jhomsa was less disturbed and sparse population inhabitant, less disposal of wastage where as Butwal Tinau was dense inhabitant then Jhomsa and lower stream that receive all disposal from upstream population.

Table 1. Physiochemical Parameters of water samples of Tinau River (Summer) (n=3)

Parameters	Jhomsa	Dobhan	Chidiya Khola	Butwal Tinau	Average
Temperature	$21.2 \pm 1.02$	$25.2 \pm 1.21$	$26.4 \pm 0.98$	$29.2 \pm 1.12$	$25.58 \pm 2.82$
Transparency	$115.2 \pm 2.1$	$109.6 \pm 1.12$	$107.6 \pm 1.98$	$100 \pm 2.21$	$108.1 \pm 5.4$
Turbidity	$8.74 \pm 0.98$	$9.04 \pm 0.56$	$8.62 \pm 0.96$	$9.62 \pm 1.02$	$9.005 \pm 0.34$
T.D.S (mg/L)	$131.8 \pm 3.1$	$158.6 \pm 3.23$	$160 \pm 1.23$	$204.8 \pm 3.23$	$163.8 \pm 17.36$
E.C ( $\mu\text{s/cm}$ )	$87 \pm 1.34$	$89 \pm 2.0$	$93 \pm 2.1$	$97 \pm 2.34$	$91.5 \pm 3.84$
pH	$7.82 \pm 0.23$	$7.82 \pm 0.34$	$7.06 \pm 0.31$	$8.4 \pm 0.51$	$7.775 \pm 0.48$
Alakinity (mg/L)	$24.2 \pm 1.12$	$36.2 \pm 2.13$	$32.8 \pm 1.12$	$27 \pm 0.51$	$30.05 \pm 4.62$
Total Hardness (mg/L)	$158.2 \pm 1.23$	$164.2 \pm 2.31$	$162 \pm 2.13$	$204.4 \pm 2.13$	$172.2 \pm 18.9$

Dissolved oxygen (mg/L)	7.18±1.25	6.86±1.12	6.9±1.21	6.32±1.22	6.815±0.29
Chloride (mg/L)	6.64±±0.81	7.56±±0.71	7.16±±0.51	7.98±±0.55	7.335±0.49
Nitrogen (mg/L)	0.054±0.01	0.84±0.15	0.7±0.06	0.96±0.21	0.629±0.34
Phosphate(mg/L)	0.42±0.07	0.82±0.09	0.32±0.07	1.48±0.16	0.76±0.06

**Table 2. Physiochemical Parameters of water samples of Tinau River (Rainy Season; Monsoon) (n=3).**

Parameter	Jhomsa	Dobhan	Chidiya Khola	Butwal Tinau	Average
Temperature	28.2±1.60	31.2±2.10	31.4±1.28	33±2.10	30.95±2.0
Transparency	55.8±2.1	9±1.21	35±2.10	5±1.20	26.2±1.8
Turbidity	7.06±2.10	9.21±1.56	9.56±2.1	11.02±1.23	9.725±1.92
T.D.S (mg/L)	237.2±2.1	267.6±4.23	237.4±3.56	320.6±4.23	265.7±3.06
E.C (µs/ cm)	91±2.43	87±4.67	91±3.20	95±3.21	91±3.27
pH	7.24±2.13	7.54±2.13	7.16±2.10	8.1±2.13	7.51±0.67
Alakinity (mg/L)	30.2±1.23	32.2±3.41	30.8±2.13	25±3.24	29.55±3.12
Total Hardness (mg/L)	120.8±4.50	161.4±4.56	133.4±4.35	199±2.75	153.7±4.7
Dissolve oxygen (mg/L)	7.72±0.26	7.46±0.14	7.76±0.87	6.44±0.09	7.395±0.52
Chloride (mg/L)	7.68±0.4	8.82±0.8	7.66±0.9	8.82±0.5	8.245±0.70
Nitrogen (mg/L)	0.72±0.11	0.76±0.17	0.6±0.16	0.96±0.09	0.76±0.15
Phosphate(mg/L)	1.04±0.12	1.2±0.30	0.96±0.12	1.34±0.16	1.135±0.18

**Table 3. Physiochemical Parameters of water samples of Tinau River (Winter Season; Post Monsoon) (n=3)**

Parameter	Jhomsa	Dobhan	Chidiya Khola	Butwal Tinau	Average
Temperature	10.6±3.0	12.2±2.8	15.4±3.2	18±2.45	14.05±3.3
Transparency	132.2±6.1	121.2±2.90	115.4±3.45	109.8±8.45	119.65±9.98
Turbidity	8.34±0.23	8.82±0.45	8.48±0.67	9.58±0.82	8.81±0.56
T.D.S (mg/L)	163.6±1.67	201.2±2.87	168.6±2.45	190.4±3.65	180.95±1.80
E.C (µs/ cm)	85.0±4.23	99.0±2.13	96.0±2.65	98.2±3.56	94.50±3.45
pH	6.74±0.49	8.08±0.87	6.54±0.59	8.42±0.66	7.45±0.97
Alkalinity (mg/L)	36.6±3.23	33.6±4.21	36.6±3.39	29±2.86	33.95±3.59
Total Hardness (mg/L)	76.2±8.12	102.6±8.70	94.2±7.45	181±9.12	113.50±12.09
Dissolve oxygen (mg/L)	8.9±0.98	8.26±0.46	8.52±0.68	7.22±0.78	8.23±0.64
Chloride (mg/L)	6.8±0.54	7.68±0.62	7.52±0.13	7.8±0.23	7.45±0.45
Nitrogen (mg/L)	0.52±0.14	0.66±0.21	0.7±0.12	0.84±0.09	0.66±0.14
Phosphate(mg/L)	1.0±0.11	1.14±0.45	0.82±0.21	1.42±0.20	1.10±0.25

**Turbidity:** Turbidity represents the important aspect of water quality. The average value of turbidity in present study ranged from 8.81 to 9.72 NTU (Tables 1-3). The value was lowest in Jhomsa (7.06 NTU) and highest in Butwal Tinau (11.26 NTU) during mid monsoon (Table 2). The average value of turbidity in all sites except Butwal Tinau was found within the EC and NBSM standards (1-10 NTU) set for the surface water used for potable abstractions. The value although less than the EC and NBSM standards but the value of sites Dobhan and Butwal showed to cross the maximum limits during mid monsoon. The high turbidity throughout the sampling period suggested that discharges from domestic effluents and runoff from agricultural activities that reach the river may be large or small particulates that are not settled to bottom CPCB (1996). The value of turbidity of study area

was somewhat similar reported by Malla (2009), it shows that the quality of water is decreasing day by day. The value of Turbidity of water sampling sites was significantly similar in Jhomsa and Chidiya Khola during pre monsoon and winter whereas in monsoon Dobhan and Chidiya Khola show the same trend.

**Total Dissolved Solid (TDS):** Pollution is the main cause of total dissolved solid. There may be other causes of TDS in the river water e.g. sewage discharge, runoff, irrigation water leaching and landslide. The water becomes potable when the concentration of TDS is less than 1000 mg/L (WHO, 2006). In present study the average value of TDS ranged from 163.8 to 265.7 mg/L (Tables 1-3). The highest value of TDS (320.6 mg/L) was observed in monsoon at Butwal sites and lowest (131.8 mg/L) in summer at Jhomsa sites (Tables 1-2). But the value of

TDS was far below the permissible level of drinking water standards of WHO and EC (Table 4). The higher values during monsoon and summer might be due to the water loss by evaporation in summer which increase particle concentration and increase sedimentation in rainy season Dixon and Chiswell (1996) Water with high solid content is inferior and suspended solid give the water a muddy or dirty appearance and the lowest value in winter may be due to less agricultural activity in upstream in this season. During present investigation total dissolved solid were found to be within the desirable limit *i.e.* 500 mg/L.

**Electric Conductivity:** Conductivity depends on the presence of ions, their total concentration, mobility, valences and on the temperature of measurement (APHA 1999). The greater amount of dissolved solid in river water indicates the greater value of ions in the same water by Bhatt *et al.* (1999). In the present study area the average value of conductivity varied from 91 to 94.5  $\mu\text{s/cm}$ , with the highest value (99  $\mu\text{s/cm}$ ) was recorded in Dobhan and lowest value (85 $\mu\text{s/cm}$ )in Butwal sites during winter (Tables 1-3). The EC value of present study was less than the study done by Sharma (2003), but similar to Jha *et al.* (2007) in Tinau river. A higher value during monsoon can be attributed to the liberation of ions from decomposed plant debris, chemicals and may be due to excessive loss of water by evaporation which in turn increases the concentration of salts. Similar result was obtained by Dangol and Lacoul, (1996). However Udash (1996) recorded higher values just after monsoon. Comparatively lower value during monsoon occurs due to the dilution by rain

Trivedy and Gudekar (1985). During the present investigation the average value of conductivity was found to be more or less similar in all study sites and within the EC standards *i.e.* 400  $\mu\text{s/cm}$ . **pH:** pH is one of the most important factors indicating acidity or alkalinity of water and frequently used in water chemistry to measure the water quality in the chemical and biological system of natural water. Natural water usually has pH value 7.0 sudden changes in the pH value indicate water pollution (APHA, 1992). The pH of ground water ranged between 5.45 to 7.8 and that of river water ranged from 6.5 to 7.6. The WHO and EC standard for pH is 6.5 to 8.5 (Table 4). Natural water usually have the pH values in between 6 to 8 and most are slightly basic because of presence of bicarbonates and carbonates of alkali and alkaline earth metals. During present investigation the river water was found alkaline throughout the study period, the average pH value during present study ranged from 7.45-7.77 (Tables 1-3). Comparatively higher values were obtained during winter and pre-monsoon and the lowest value of pH during monsoon. A similar result was obtained by Sharma *et al.* (2003) and Jha *et al.* (2007) in the same river may be due to the heavy rainfall which is free of chemicals. The average in the Tinau river in a study during 1994-95 was 8.29 (Sharma, 1996). A decade later, the mean pH value was 8.5 (Jha, 2006). There was no decline in pH that time. Average value of pH was found to be more or less similar in all study sites and within the EC, WHO standard (6.5-8.5). The mean pH value at present study shows less declination.

**Table 4. Drinking Water standards**

PARAMETERS	UNIT	WHO*	EC**
Temperature	$^{\circ}\text{C}$	-	25 - 25
Turbidity	NTU	5	1 - 10
Total Dissolved Solids	mg/L	1000	1500
pH		6.5 - 8.5	6.5 - 8.5
Conductivity	$\mu\text{s/cm}$	-	400
Total Hardness as $\text{CaCO}_3$	mg/L	500	-
Chloride	mg/L	250	25
Sulphate	mg/L	400	25
Calcium	mg/L	-	100
Magnesium	mg/L	-	30 - 50
Sodium	mg/L	200	20 - 175
Nitrogen – Ammonia	mg/L	-	0.04 - 0.4

Nitrogen – Nitrite	mg/L	1.0	-
Nitrogen – Nitrate	mg/L	1.0	5 - 10
Ortho- Phosphate	mg/L	-	0.4 - 5.0

\*\* European Community, Directive 80/778/EEC

\* World Health Organization, 1984

**Alkalinity:** Alkalinity of water is its capacity to neutralize strong acid which is due to the concentration of major ions  $\text{HCO}_3^-$ ,  $\text{CO}_3^{2-}$ , and  $\text{OH}^-$ . Alkalinity is an estimate of the ability of water to resist change in pH upon abdication of acid. The average value of alkalinity during present study ranged from 29.55 to 33.95 mg/L (Tables 1-3). The alkalinity in the present study was only due to bicarbonates where the carbonates were nil. According to Jhingran (1975), the pH value ranged from 4.5 to 8.3 has practically no carbonates, which supported the present study. The alkalinity value was recorded highest in winter season (36.6 mg/L) at Jhomsa and Chidiya Khola sites and lowest in pre monsoon (24.2 mg/) at Jhomsa sites (Tables 1-3). The highest alkalinity value in winter season may be due to less water volume and more bicarbonates ions than other seasons. The present values were more than the values recorded by Paudyal (2001) in Sundarijal. Alkalinity above 150 mg/L is found to be conductive to higher production (Ball 1949).

**Total Hardness:** Total hardness is defined as the sum total of concentration of calcium and magnesium ions dissolved in water. During the present study the average value of hardness was found in between 113.5 to 172.2 mg/L (Tables 1-3). The maximum values were obtain during pre-monsoon at Butwal site i.e. 204.4 mg/L and lowest in winter at Jhomsa i.e. 76.2 mg/L, thereafter the gradual decline was observed onward rainy season and reached its lowest value in winter (Tables 1-3). Similar trend was recorded by Dangol and Lacoul (1996) in Punyamati River, Paudyal (2001) in Sundarijal. Higher values in pre-monsoon may be due to the higher temperature, which increases concentration of salts by excessive evaporation. Depletion of hardness in rainy season may be due to the dilution by rainwater. The increase in hardness can be attributed to the decrease in water volume and increase in the rate of evaporation at high temperature, high loading organic substances, detergent, chloride and other polluted by Rajgopal *et*

*al.* (2010). According to report of WHO tolerable limit of total hardness is 250mg/L. Hardness may not be polluted but it is not good to health either.

**Dissolved Oxygen:** Oxygen distribution is important for the direct needs of many organism and affect the solubility and availability of many nutrients and therefore the productivity of aquatic ecosystem (Wetzel 1968). During the present study average value of dissolved oxygen recorded in between 6.81 to 8.23 mg/L (Tables 1-3). Lowest value (6.32 mg/L) of DO was obtained during the pre-monsoon. Rain, then improves it in monsoon and reached its highest peak (8.9 mg/L) in winter. This trend showed inverse relation to the temperature cycle. This same trend was found by Simkhadka (2003) in Gaidawa Lake, Rupandehi. Lower value of DO during the pre-monsoon may be due to higher rate of anthropogenic activities. Decomposition of organic matter may be an important factor in consumption of DO, which become more vigorous in warm weather (Badge and Verma 1985). In monsoon may be due to the circulation and mixing by inflow after monsoon rain Hannan *et al.* (1978). With the progression of winter, DO increase sharply to its highest peak which may be due to the circulation by cooling and drawdown of dissolved oxygen in water (Rao 1979; Poudel *et al.* 2013). Low content of DO for drinking water is a sign of organic pollution. Tolerance limit of DO for drinking water is not less than 6 mg/L (Kudesia 1985) but during the present study the value was found be just near to lower limit in pre-monsoon and monsoon in Butwal station it shows it is going to be polluted. The saturation level of the dissolved oxygen is 14-15 ppm at 0°C in fresh clean water (Ambashts 1975).

**Chloride:** Chloride is generally indicator of large amount of organic matter, which suggests the positive influence over microbial growth and subsequently lower public health quality. High chloride content may cause corrosion of the pipes and change organoleptic quality of drinking water. The effluents with higher chlorides are not useful for irrigation purpose because they may be

toxic to fruit crops by scorching the leaves (Schreuder and Brewer, 2001). The average chloride value in present study ranged from 7.33 to 8.24 mg/L (Tables 1-3), with the highest value was recorded (8.82 mg/L) at Dobhan station during monsoon while the lowest value was observed at Jhomsa station (6.64 mg/L) during pre-monsoon. The higher content of chloride during monsoon in all sites may be due to animal organic like human faeces and sewage inflow. Jhomsa is the upstream so it has less value but Butwal receive all water flow through different stations and falls on downstream. Chloride increases with the increasing degree of eutrophication, the value lie within the range as prescribed by WHO and EC. The high level of chloride influences the physiology and reproductive biology of aquatic organism (Kinne 1971).

**Total Nitrogen:** Total nitrogen is found in the form of nitrate and ammonia. Nitrate is the oxidation state of nitrogen. Oxidation of ammonia first produces nitrite and then nitrate. Ammonia is present naturally in surface water, ground water and domestic sewage. This nitrogen sources is quantitatively minor in comparison to that generated by bacterial decomposition (Wetzel 1968). The average value of total nitrogen in present study sites ranged from 0.629 to 0.76 with highest value recorded (0.96 mg/L) in in pre and mid monsoon season at Butwal station and lowest (0.52 mg/L) in winter at Jhomsa station (Tables 1-3). The value of nitrogen was nearly equal in all sites during the seasons. Average value of total nitrogen was found to be more or less similar in all study sites and within range value of EC standard (0.004-0.8) (Table 4). The higher nitrogen in monsoon may be due to accumulation of organic matter, agricultural runoff from the catchments area and higher microbial activities or might be due to leaching nitrate from nearby agricultural field. Hence, the Butwal Tinau can be considered as ultra-oligotrophic according to the criteria proposed by Wetzel (1983).

**Total Phosphorous:** Total phosphorous in river water occur both organic and inorganic forms. Phosphorous is the major nutrient that triggers eutrophication surface water. The domestic waste, agricultural runoff water from catchment

area release phosphorous to the natural water and the majority of organic phosphate present in the form of orthophosphate ( $\text{PO}_4^{3-}$ ). The sediment flora is important in increasing concentration of phosphorous dissolved in interstitial water of the sediments (Fleisher 1978). During the present investigation the average value of phosphorous was found in between (0.76 to 1.13 mg/L) (Tables 1-3). The highest value was found during monsoon and the lowest during pre monsoon. The value was lowest during pre-monsoon *i.e.* 0.32 mg/L at Chidiya Khola station and highest during pre monsoon *i.e.* 1.48 mg/L at Butwal station. The trend is similar to Pejwar *et al.* (2002) in Gandhisagar lake, Nagpur, India. Higher values of phosphates were recorded during monsoon. Tinau river receives surface runoff, as the river is flow from near cultivate lands. Soils cultivated for agriculture purposes were fertilized with phosphates which allow phosphates to enter into water particularly with surface runoff. Detergents also released phosphate concentration to water bodies. Lower concentration of phosphorous during summer may be due to the high rate of consumption by macrophytes and algae. Addition of phosphorous in different form cause enhanced or explosive growth of algae and/or aquatic weeds might lead to eutrophic deterioration of river.

## CONCLUSION

The water quality of Tinau River and its feeding streams is good for supplying it as drinking water to the Butwal town. The present study also states that overall water quality within river area is natural. Most of the values obtained during the study period were within the WHO, EC and NBSM guidelines values. The temporal variations of parameters have been significantly high during monsoon in Butwal station. The dense vegetation cover in the Jhomsa, Dovan and Chidiyakhola sub-watershed ensures a steady flow of water from the area. All the physicochemical parameters are within the standard for drinking water except turbidity and pH (Butwal station) and raw water source for potable abstraction.

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