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Seasonal Variation in Limno-Chemical Profile of Dikhu River Stretch in Nagaland

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Abstract: The present research work is an attempt to analyze the changes in physic-chemical characteristics of Dikhu River stretch in Nagaland. The work encompasses the seasonal fluctuations in the river Dikhu which affects river ecology to great extent and other correlative biological factors. Hence this work could be used by many researchers in the ecological research of river ecosystem to have better understanding of the biological systems and effect of the fluctuations on them.
Keywords: Dikhu River, drainage, basin, ecosystem

INTRODUCTION

The river ecosystem is formed by the interaction between river biota and their hydro-geochemical environment. It is characterized by the continuous transport of various substances, such as organic matter and the nutrients, from the soils of the drainage basin to the river and from there, downstream with the flowing water. River ecosystem contains many other smaller types of ecosystems, including many of that do not lie within the open-water channel. River ecosystem is also unique in that they are relatively small volume, but open, ecosystems with high rates of energy throughout. Therefore, understanding a river ecosystem is clearly a challenging and complicated task.

Nagaland is a hilly mountainous state in the north- east corner of the country. The state is located between $25^{0}.6'$ and $27^{0}.4'$ N and between $93^{0}.20'$ and $95^{0}.13'$ E. It encompasses geographical area of 16,579 km^3. River Dikhu, which has a total length of about 171 km, originates from Nuroto Hill area in Zunheboto district. The catchment area is around 2996 km^2. The measurement point of Dikhu River in Nagaland is from Phuye/ Surumi area to Naginimora. The river traverses towards north along the border of Mokokchung and Tuensang districts. The main tributaries of river Dikhu are Yangyu of Tuensang district and Nanung in the Langpangkong range in Mokokchung district. The river flows further northward and leaves the hill near Naginimora and finally merges with the Brahmaputra River in the plains of Assam.

The physico-chemical and biological characteristics of water bodies have been studied by several researchers from time to time (Kaur and Joshi, 2003; Mishra and Tripathi, 2003; Saxena *et al*., 2005; Zafar and Sultana, 2008; Singh *et al*., 2009; Manikannan *et al*., 2011). In Nagaland, thorough study of water quality variable of the river Dikhu is not yet documented. In view of this, the present investigation has been taken up and due emphasis is given to study the various physico-chemical parameters during different seasons of the year.

MATERIAL & METHODS

The present research work on Limnological analysis of Dikhu river was carried out from April 2015 to March 2016. For the present investigation, five sampling sites were selected on the basis of accessibility, vegetation, and nearness below and above the dam site. Two sampling stations were selected from each site.

Physico-chemical Parameters

pH and conductivity was measured with the help of portable digital pH meter (OAKTON). The temperature of surface water and air was recorded by using standard Celsius mercury thermometer. Turbidity was measured an electronic turbidity meter. T.D.S. was recorded with the help of a digital T.D.S. meter (OAKTON). For chemical variables of water like dissolved oxygen, free Carbon dioxide, total alkalinity and total hardness etc, the samples were collected in BOD bottles and analyzed in the laboratory following the standard method of APHA (2005) and Trivedy and Goel (1986). Dissolved oxygen was determined by

Winkler's method after fixing the oxygen on the spot, while the remaining chemical parameters (alkalinity and hardness) were estimated with the help of compact water analysis kit (Aquamerck).

Table 1:

S.N.	Site No.	Type	Name	Coordinates
1.	Station I	Riffles	Changtongya	26º31´30" N L and 94º41´13" E L
2.	Station II	Pool	Chuchuyimpang	36º32´4" N L and 94º41´46" E L
3.	Station III	Meander	Longkong	26º32´12" NL and 94º42´4" E L
4.	Station IV	Vegetation Area	Longmisa	26º32´22" N L and 94º42´15" E L
5.	Station V	Open	Longsa	26°20´9" N L and 94°38´29" E L

RESULTS

The air temperature (°C) ranged between 16°C to 29.0°C at all the five sampling stations during the present research time. The water temperature (°C) ranged between 12.0°C and 25.0°C. At site 1, the water temperature was 12.0°C and 24.0°C, with a mean±SD of 19.25±5.01, the Winter, Spring, Summer and Autumn averages were 12.67, 17.67, 23.33 and 23.33 respectively. At site 2, the water temperature was 13.0°C and 24.0°C, with a mean±SD of 19.08±4.67, the Winter, Spring, Summer and Autumn averages were 13.00, 17.67, 23.00 and 22.67 respectively. At site 3, the water temperature was 13.0°C and 24.0°C, with a mean±SD of 19.16±4.66, the Winter, Spring, Summer and Autumn averages were 13.33, 17.00, 23.00 and 23.33 respectively.

At site 4, water temperature was recorded as 13.0°C and 24.0°C, with a mean±SD of 19.16±4.48, the Winter, Spring, Summer and Autumn averages were 13.67, 17.00, 23.33 and 22.67 respectively. At site 5, water temperature was recorded as 13.0°C and 25.0°C, with a mean±SD of 19.66±4.61, the Winter, Spring, Summer and Autumn averages were 13.67, 18.00, 23.67 and 23.33 respectively.

The annual thermal regime of a river, according to Smith [1], is one of the important water quality parameters and most of the physical, chemical and biological properties of water are dependent on it. Several observers have kept a stretch of stream under observation for a period and have found, that superimposed upon the seasonal changes, there are diurnal cycles in temperature. These may amount to 6˚C in small streams in summer time [2], with lower values in large rivers. The present research revealed the air temperature in Dikhu river stretch between 16.20 to 17.00 °C. In winter time, however, ice and snow form an insulating layer, and even in extreme climates such as that of Alaska, the water temperature does not fall below 0˚C [3]. In spring time snow melt water may keep the temperature below that of the air for quite some time [3]. Streams flowing underground or through man-made culverts may be cooled or warmed in the process according to the season, and wind or shade may cause considerable changes. In contrast to lakes, rivers normally show little stratification because of their turbulent flow [4].

Reports of the air temperature needed to cause its formation vary from -15.6˚C to -23˚C [7]. Stream temperature is spatially and temporally variable [5, 6] and is a function of the source water temperature and its transport time [8]. During the present research period, the Dikhu River witnessed the water temperatures range between 9.10 to 10.95°C. Temperatures may be relatively stable in large rivers with low flow velocities, but can fluctuate quickly in steep shallow streams. Seasonal variation also results from changes in the hydrologic regime [8] and air temperature [1]. Smith [1] found that stream temperatures in Great Britain were highly correlated to air temperature. In addition, other studies show that elevation, riparian vegetation, and channel width influence stream temperature [9, 10]. These results indicate that readily available landscape variables, such as elevation, air temperature, and riparian condition [11, 12], may explain some variability in stream temperature.

Current Velocity

The current velocity ranged between 24.8 and 59.2. At site 1, the current velocity was 24.8 and 57.5, with a mean±SD of 35.72±11.23, the Winter, Spring, Summer and Autumn averages were 28.86, 28.39, 53.50 and 32.15 respectively. At site 2, the current velocity was 25.3 and 56.9, with a mean±SD of 36.11±10.74, the Winter, Spring, Summer and Autumn averages were 29.87, 28.76, 52.87 and 32.97 respectively. At site 3, the current velocity was 25.6 and 58.0, with a mean±SD of 36.22±10.79, the Winter, Spring, Summer and Autumn averages were 29.37, 29.27, 53.17 and 33.09 respectively.

At site 4, current velocity was recorded as 26.3 and 59.2, with a mean±SD of 36.82±11.68, the Winter, Spring, Summer and Autumn averages were 29.30, 28.83, 55.20 and 33.97 respectively. At site 5, current velocity was recorded as 25.6 and 58.9, with a mean±SD of 36.93±11.75, the Winter, Spring, Summer and Autumn averages were 29.13, 29.33, 55.47 and 33.80 respectively.

Transparency

The transparency ranged between a minimum of 0.40 to a maximum of 1.01 during the study period. At site 1, transparency was recorded as 0.40 and 0.90, with a mean±SD of 0.66±0.16, the Winter, Spring, Summer and Autumn averages were 0.50, 0.68, 0.60 and 0.86 respectively. At site 2, transparency was recorded as 0.49 and 0.95, with a mean±SD of 0.69±0.15, the Winter, Spring, Summer and Autumn averages were 0.53, 0.70, 0.67 and 0.88 respectively. At site 3, transparency was recorded as 0.42 and 0.89, with a mean±SD of 0.67±0.16, the Winter, Spring, Summer and Autumn averages were 0.49, 0.71, 0.65 and 0.85 respectively.

At site 4, transparency was recorded as 0.56 and 0.92, with a mean±SD of 0.72±0.13, the Winter, Spring, Summer and Autumn averages were 0.62, 0.72, 0.65 and 0.90 respectively. At site 5, transparency was recorded as 0.43 and 1.01, with a mean±SD of 0.72±0.19, the Winter, Spring, Summer and Autumn averages were 0.49, 0.75, 0.69 and 0.97 respectively. Streams are slightly turbid even at times of very low discharge [4]. Dorris *et al*. [13], who made a long series of measurements, found a good relationship between the discharge and the turbidity, and this is a fairly general phenomenon [4]. We recorded a transparency of 0.49 to 1.71 at different study sites of Dikhu River, which is purely a stream water.

Conductivity

The conductivity ranged between a minimum of 87.0 to a maximum of 185.2 during the study period. At site 1, conductivity was recorded as 87.5 and 182.5, with a mean±SD of 121.33±31.20, the Winter, Spring, Summer and Autumn averages were 125.53, 102.47, 160.87 and 96.47 respectively. At site 2, conductivity was recorded as 89.0 and 181.0, with a mean±SD of 124.26±33.24, the Winter, Spring, Summer and Autumn averages were 123.93, 101.47, 175.00 and 96.67 respectively. At site 3, conductivity was recorded as 89.5 and 185.2, with a mean±SD of 121.87±30.90, the Winter, Spring, Summer and Autumn averages were 125.27, 102.00, 160.33 and 96.00 respectively.

At site 4, conductivity was recorded as 89.5 and 185.2, with a mean±SD of 122.16±30.67, the Winter, Spring, Summer and Autumn averages were 125.27, 102.00, 160.33 and 96.00 respectively. At site 5, conductivity was recorded as 87.0 and 182.0, with a mean±SD of 120.90±31.18, the Winter, Spring, Summer and Autumn averages were 125.27, 102.00, 163.33 and 96.00 respectively. Conductivity is a good major of concentration of charged ions in waters and is strongly influenced by landscape scale conditions. The geology in the catchment is the source of the ions that act as conductors of electricity [14]. The Dikhu river has high conductivity ranging between 214.00 to 257.00, owing to the turbulent nature of water and rocky stream texture. Urban and agricultural land uses have been shown to increase conductivity levels [15]. It has been established that there are seasonal differences in conductivity that generally result from a negative relationship with discharge volume [15, 16].

Dissolved oxygen

The dissolved oxygen ranged between a minimum of 8.30 to a maximum of 13.1 during the study period. At site 1, dissolved oxygen was recorded as 10.7 and 12.0, with a mean±SD of 11.48±0.54, the Winter, Spring, Summer and Autumn averages were 11.67, 11.83, 10.87 and 11.57 respectively. At site 2, dissolved oxygen was recorded as 8.60 and 12.0, with a mean±SD of 11.50±1.33, the Winter, Spring, Summer and Autumn averages were 11.33, 11.03, 8.90 and 10.77 respectively. At site 3, dissolved oxygen was recorded as 8.90 and 13.1, with a mean±SD of 10.65±1.45, the Winter, Spring, Summer and Autumn averages were 12.00, 11.47, 8.93 and 10.23 respectively.

At site 4, dissolved oxygen was recorded as 10.1 and 13.0, with a mean±SD of 11.68±0.79, the Winter, Spring, Summer and Autumn averages were 11.90, 12.33, 10.97 and 11.53 respectively. At site 5, dissolved oxygen was recorded as 8.30 and 12.0, with a mean±SD of 10.74±1.47, the Winter, Spring, Summer and Autumn averages were 11.53, 11.80, 8.97 and 10.67 respectively. Welch [17] pointed out that under natural conditions the running waters typically contain relatively high concentration of dissolved oxygen tending towards saturation. According to the author, the levels of dissolved oxygen in the rivers are perhaps of the greatest importance to the survival of the aquatic organisms.

Dissolved oxygen (DO), a regulating parameter in stream ecology, is related to the biological oxygen demand in the stream [5, 18]. During the present research periods, the overall dissolved oxygen in Dikhu river system ranged from 8.94-9.80 mg/l. The modest levels of dissolved oxygen in Dikhu river water explain the good water quality condition, which is optimum for the livelihood of the aquatic fauna. Microbial biomass increases in response to the addition of nutrients and more oxygen is consumed. Oxygen is slowly replenished by atmospheric uptake, photosynthetic additions, and the turbulent mixing of oxygen and water and in unpolluted headwater streams, DO is inversely related to current velocity [5]. In small turbulent streams the oxygen content is normally near or above saturation. In fact, even in torrential stream the oxygen content varies seasonally and from source to mouth. In many streams there is also a diurnal variation in oxygen content. In large rivers like the Mississippi and the Amazon, high water is accompanied by lowered oxygen concentrations, and these are brought about by the wash-in of organic matter and the decrease of photosynthesis caused by turbidity [19].

Free Carbon Dioxide

The free carbon dioxide ranged between a minimum of 4.3 to a maximum of 5.9 during the study period. At site 1, free carbon dioxide was recorded as 4.3 and 4.8, with a mean±SD of 4.51±0.19, the Winter, Spring, Summer and Autumn averages were 4.50, 4.40, 4.70 and 4.47 respectively. At site 2, free carbon dioxide was recorded as 4.5 and 4.9, with a mean±SD of 4.725±0.14, the Winter, Spring, Summer and Autumn averages were 4.80, 4.67, 4.80 and 4.63 respectively. At site 3, free carbon dioxide was recorded as 4.40 and 5.10, with a mean±SD of 4.78±0.22, the Winter, Spring, Summer and Autumn averages were 4.87, 4.57, 4.97 and 4.73 respectively.

At site 4, free carbon dioxide was recorded as 4.9 and 5.3, with a mean±SD of 5.16±0.12, the Winter, Spring, Summer and Autumn averages were 5.00, 5.17, 5.27 and 5.23 respectively. At site 5, free carbon dioxide was recorded as 5.20 and 5.9, with a mean±SD of 5.49±0.21, the Winter, Spring, Summer and Autumn averages were 5.30, 5.37, 5.70 and 5.60 respectively. Upadhyay *et al*. [20] worked on limnochemistry and nutrient dynmaics in Upper lake Bhopal, India and reported the fluctuations in free carbon dioxide pertinent to change in oxygen profile, depending upon the seasons of the year.

pH

The pH ranged between a minimum of 6.9 to a maximum of 7.8 during the study period. At site 1, pH was recorded as 6.9 and 7.2, with a mean±SD of 7.06±0.11, the Winter, Spring, Summer and Autumn averages were 7.20, 7.07, 7.07 and 6.93 respectively. At site 2, pH was recorded as 6.9 and 7.3, with a mean±SD of 7.07±0.13, the Winter, Spring, Summer and Autumn averages were 7.27, 7.07, 7.00 and 6.97 respectively. At site 3, pH was recorded as 7.0 and 7.8, with a mean±SD of 7.42±0.36, the Winter, Spring, Summer and Autumn averages were 7.80, 7.23, 7.57 and 7.10 respectively.

At site 4, pH was recorded as 7.0 and 7.6, with a mean±SD of 7.33±0.21, the Winter, Spring, Summer and Autumn averages were 7.53, 7.23, 7.33 and 7.23 respectively. At site 5, pH was recorded as 7.2 and 7.5, with a mean±SD of 7.40±0.09, the Winter, Spring, Summer and Autumn averages were 7.33, 7.40, 7.43, and 7.43 respectively. Acidification of stream water, one of the major problems of stream ecosystems worldwide, can result from anthropogenic stresses such as acid mine drainage [21] or the atmospheric deposition of nitric and sulfuric acids [8]. However, naturally acidic streams can also be found in areas with considerable humic inputs [22]. pH has been recognized as a regulating factor in aquatic systems and the biological components are severely affected at extremes of their pH tolerance. The Dikhu stream is completely alkaline with pH variance between 7.5 and 8. The alkaline nature of the Dikhu stream is an obvious situation in terms of the freshness of water, which have chances of acidification later on after the sedimentation and organic mineralization.

Alkalinity

The alkalinity ranged between a minimum of 50.00 to a maximum of 58.70 during the study period. At site 1, alkalinity was recorded as 50.00 and 52.30, with a mean±SD of 51.04±0.89, the Winter, Spring, Summer and Autumn averages were 52.20, 51.07, 50.53 and 50.37 respectively. At site 2, alkalinity was recorded as 51.00 and 57.10, with a mean±SD of 53.34±2.38, the Winter, Spring, Summer and Autumn averages were 56.27, 53.80, 51.17 and 52.13 respectively. At site 3, alkalinity was recorded as 51.00 and 58.70, with a mean±SD of 54.95±2.44, the Winter, Spring, Summer and Autumn averages were 55.17, 57.53, 53.43 and 53.67 respectively.

At site 4, alkalinity was recorded as 51.00 and 58.10, with a mean±SD of 55.10±2.83, the Winter, Spring, Summer and Autumn averages were 58.00, 56.33, 51.70 and 54.37 respectively. At site 5, alkalinity was recorded as 50.00 and 58.50, with a mean±SD of 54.12±3.41, the Winter, Spring, Summer and Autumn averages were 57.97, 55.53, 50.17 and 52.83 respectively. A commendable work has been done on total alkalinity fluctuations in upper and Lower lake. Gupta *et al.* [23] did the preliminary survey of Upper lake, Bhopal in rainy season with reference to algal flora and reported total alkalinity of 96-288. While as Upadhyay *et al.* [20] worked on limnochemistry and nutrient dynamics in Upper lake Bhopal. Bhat *et al.* [24] observed a total alkalinity of 96.25 in Upper lake, while as Talwar *et al.* [25] found to range from 114 to 432 mg/l. A general trend of an increase in the alkalinity value was observed in the post – monsoon season, which is in coherence with the present findings. Sreenivasa & Suparna (2014) enumerated water quality parameters of Lower lake, Bhopal and reported total alkalinity value of 680, 715 and 670 in pre-monsoon, monsoon and post monsoon seasons respectively.

Hardness

The hardness ranged between a minimum of 52.00 to a maximum of 60.60 during the study period. At site 1, hardness was recorded as 52.10 and 58.70, with a mean±SD of 55.35±2.65, the Winter, Spring, Summer and Autumn averages were 58.33, 56.43, 52.20 and 54.43 respectively. At site 2, hardness was recorded as 55.00 and 57.70, with a mean±SD of 56.39±1.11, the Winter, Spring, Summer and Autumn averages were 57.60, 56.73, 55.07 and 56.17 respectively. At site 3, hardness was recorded as 53.00 and 60.30, with a mean±SD of 57.13±2.82, the Winter, Spring, Summer and Autumn averages were 57.37, 59.47, 53.60 and 58.10 respectively.

At site 4, hardness was recorded as 52.00 and 60.10, with a mean±SD of 56.40±3.30, the Winter, Spring, Summer and Autumn averages were 56.13, 59.00, 52.27 and 57.50 respectively. At site 5, hardness was recorded as 55.00 and 60.60, with a mean±SD of 58.26±2.31, the Winter, Spring, Summer and Autumn averages were 59.80, 59.50, 53.33 and 58.43 respectively. Garg and Garg [26] worked on the limnological aspects of three lakes of Bhopal and observed that the water of all the three lakes were hard with calcium contents ranging from 41.6 – 74.4 mg l^{-1} in Upper lake and 30.0 – 78.0 mg l^{-1} in Lower lake. In support to the work, Upadhyay *et al*. [20] lent support to the findings of the author. Bhat *et al*. [27] on the other hand observed a calcium hardness of 79.88 in Upper lake, Bhopal during their study period from Feb' 08 to Jan' 09.

Table 2: Physico Chemical Parameters of various study sites of Dikhu river system

	Sites	**Average ± SD**	**Min**	**Max**	**Winter Av**	**Spring Av**	**Summer Av**	**Autumn Av**
Air temperature	**Site 1**	21.66±4.47	16.00	29.00	16.67	21.00	23.33	25.67
	Site 2	22.83±4.87	16.00	29.00	17.00	21.00	28.00	25.33
	Site 3	22.66±4.69	16.00	28.00	17.00	21.00	27.67	25.00
	Site 4	23.00±5.16	16.00	29.00	16.67	20.67	28.33	26.33
	Site 5	23.00±4.95	16.00	29.00	16.67	21.00	23.33	25.67
Water Temperature	**Site 1**	19.25±5.01	12.00	24.00	12.67	17.67	23.33	23.33
	Site 2	19.08±4.67	13.00	24.00	13.00	17.67	23.00	22.67
	Site 3	19.16±4.66	13.00	24.00	13.33	17.00	23.00	23.33
	Site 4	19.16±4.48	13.00	24.00	13.67	17.00	23.33	22.67
	Site 5	19.66±4.61	13.00	25.00	13.67	18.00	23.67	23.33
Current Velocity (m/s)	**Site 1**	35.72±11.23	24.8	57.5	28.86	28.39	53.50	32.15
	Site 2	36.11±10.74	25.3	56.9	29.87	28.76	52.87	32.97
	Site 3	36.22±10.79	25.6	58.0	29.37	29.27	53.17	33.09
	Site 4	36.82±11.68	26.3	59.2	29.30	28.83	55.20	33.97
	Site 5	36.93±11.75	25.6	58.9	29.13	29.33	55.47	33.80
Transparency (Cm)	**Site 1**	0.66±0.16	0.4	0.9	0.50	0.68	0.60	0.86
	Site 2	0.69±0.15	0.49	0.95	0.53	0.70	0.67	0.88
	Site 3	0.67±0.16	0.42	0.89	0.49	0.71	0.65	0.85
	Site 4	0.72±0.13	0.56	0.92	0.62	0.72	0.65	0.90
	Site 5	0.72±0.19	0.43	1.01	0.49	0.75	0.69	0.97
Conductivity (µs/s)	**Site 1**	121.33±31.20	87.5	182.5	125.53	102.47	160.87	96.47
	Site 2	124.26±33.24	89.0	181.0	123.93	101.47	175.00	96.67
	Site 3	121.87±30.90	89.5	185.2	125.27	102.00	160.33	96.00
	Site 4	122.16±30.67	89.5	185.2	125.27	102.00	160.33	96.00
	Site 5	120.90±31.18	87.0	182.0	125.27	102.00	160.33	96.00
Dissolved Oxygen	**Sites**	**Average ± SD**	**Min**	**Max**	**Winter Av**	**Spring Av**	**Summer Av**	**Autumn Av**
	Site 1	11.48±0.54	10.7	12.0	11.67	11.83	10.87	11.57

	Site 2	11.50±1.33	8.60	12.0	11.33	11.03	8.90	10.77
	Site 3	10.65±1.45	8.90	13.1	12.00	11.47	8.93	10.23
	Site 4	11.68±0.79	10.1	13.0	11.90	12.33	10.97	11.53
	Site 5	10.74±1.47	8.30	12.0	11.53	11.80	8.97	10.67
Free Carbon dioxide (mg/l)	**Site 1**	4.51±0.19	4.3	4.8	4.50	4.40	4.70	4.47
	Site 2	4.725±0.14	4.5	4.9	4.80	4.67	4.80	4.63
	Site 3	4.78±0.22	4.4	5.1	4.87	4.57	4.97	4.73
	Site 4	5.16±0.12	4.9	5.3	5.00	5.17	5.27	5.23
	Site 5	5.49±0.21	5.2	5.9	5.30	5.37	5.70	5.60
pH	**Site 1**	7.06±0.11	6.9	7.2	7.20	7.07	7.07	6.93
	Site 2	7.07±0.13	6.9	7.3	7.27	7.07	7.00	6.97
	Site 3	7.42±0.36	7.0	7.8	7.80	7.23	7.57	7.10
	Site 4	7.33±0.21	7.0	7.6	7.53	7.23	7.33	7.23
	Site 5	7.40±0.09	7.2	7.5	7.33	7.40	7.43	7.43
Alkalinity	**Site 1**	51.04±0.89	50.00	52.30	52.20	51.07	50.53	50.37
	Site 2	53.34±2.38	51.00	57.10	56.27	53.80	51.17	52.13
	Site 3	54.95±2.44	51.00	58.70	55.17	57.53	53.43	53.67
	Site 4	55.10±2.83	51.00	58.1	58.00	56.33	51.70	54.37
	Site 5	54.12±3.41	50.00	58.5	57.97	55.53	50.17	52.83
Hardness	**Site 1**	55.35±2.65	52.1	58.7	58.33	56.43	52.20	54.43
	Site 2	56.39±1.11	55.0	57.7	57.60	56.73	55.07	56.17
	Site 3	57.13±2.82	53.0	60.3	57.37	59.47	53.60	58.10
	Site 4	56.47±3.30	52.0	60.1	57.13	59.00	52.27	57.50
	Site 5	58.26±2.31	55.0	60.6	59.80	59.50	53.33	58.43

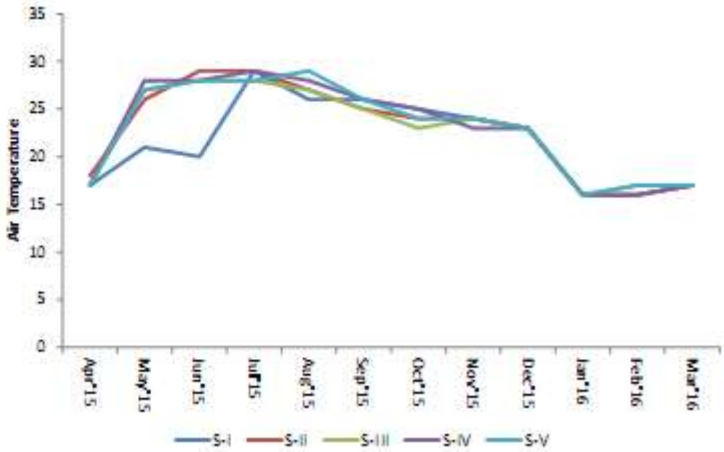

Fig-1: Air temperature fluctuations at various study sites in Dikhu river

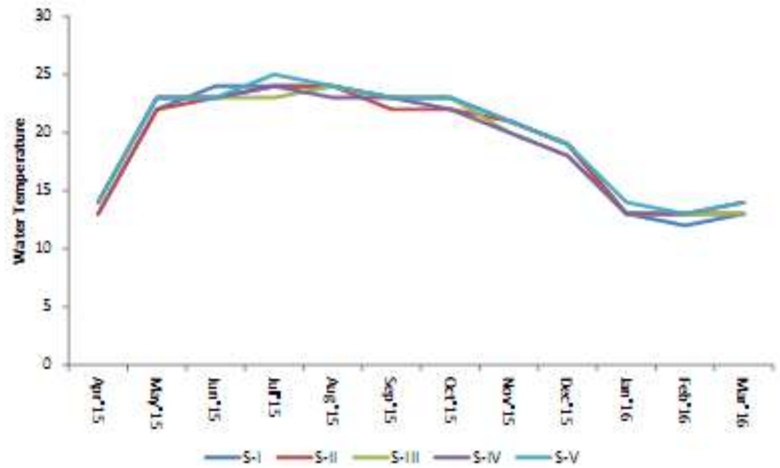

Fig-2: Water temperature fluctuations at various study sites in Dikhu river

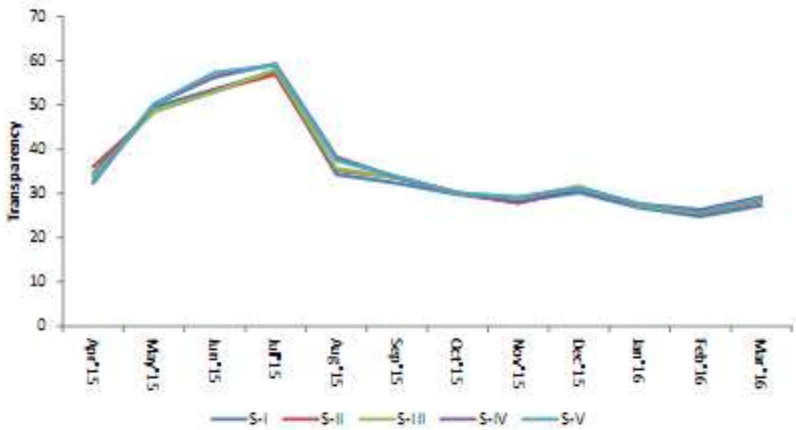

Fig-3: Transparency fluctuations at various study sites in Dikhu river

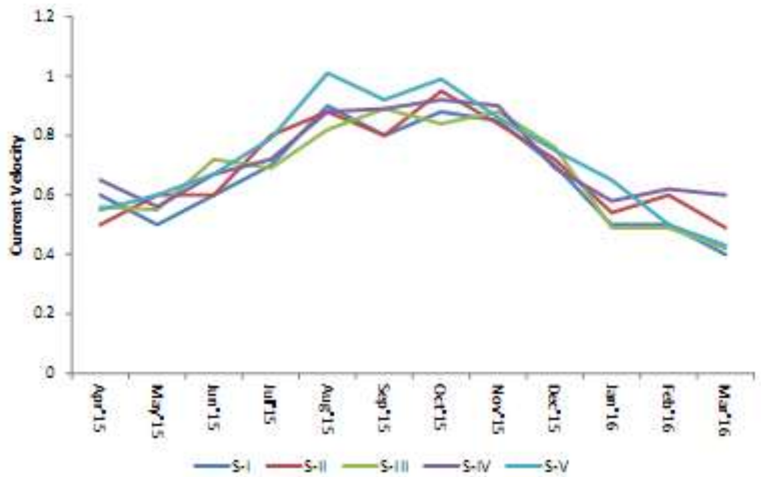

Fig-4: Current Velocity fluctuations at various study sites in Dikhu river

Fig-5: Conductivity fluctuations at various study sites in Dikhu river

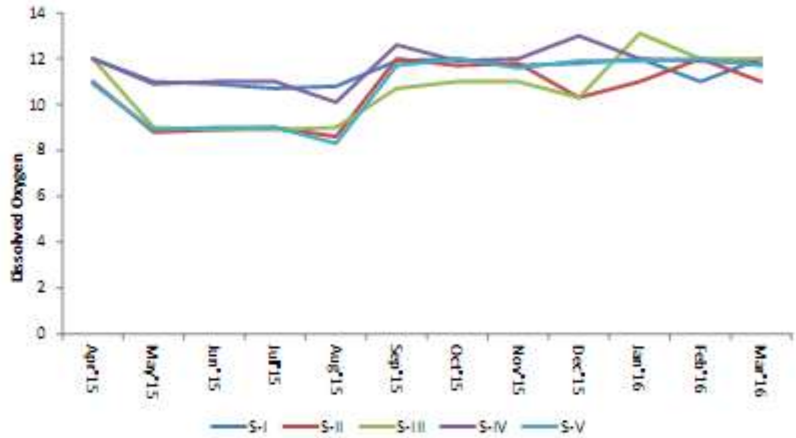

Fig-6: Dissolved Oxygen fluctuations at various study sites in Dikhu river

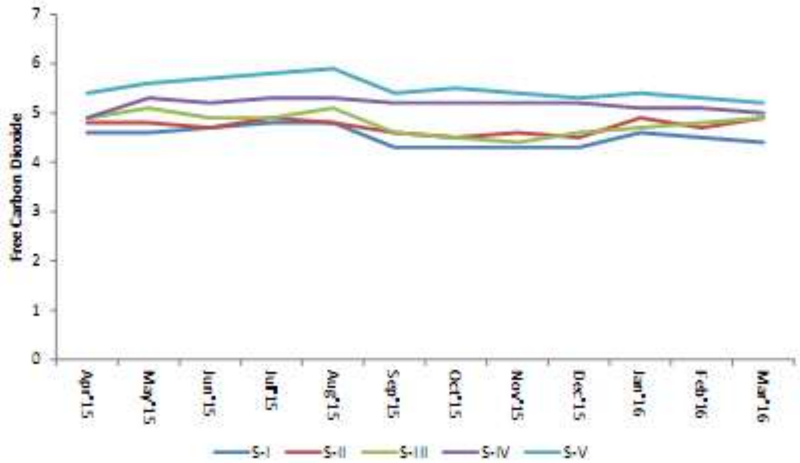

Fig-7: Free Carbon Dioxide fluctuations at various study sites in Dikhu river

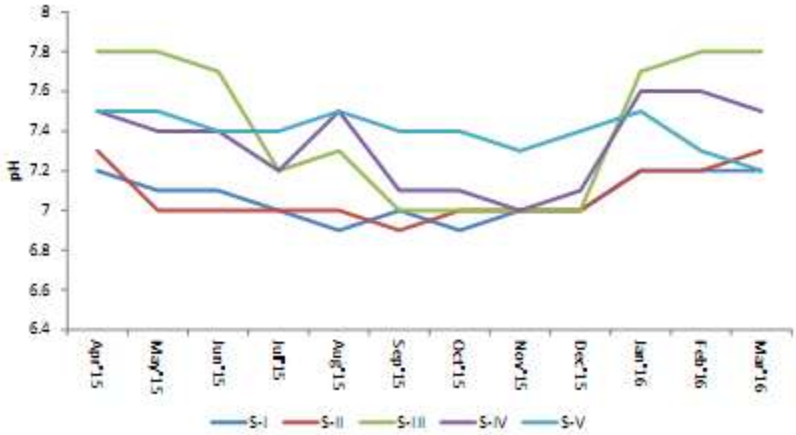

Fig-8: pH fluctuations at various study sites in Dikhu river

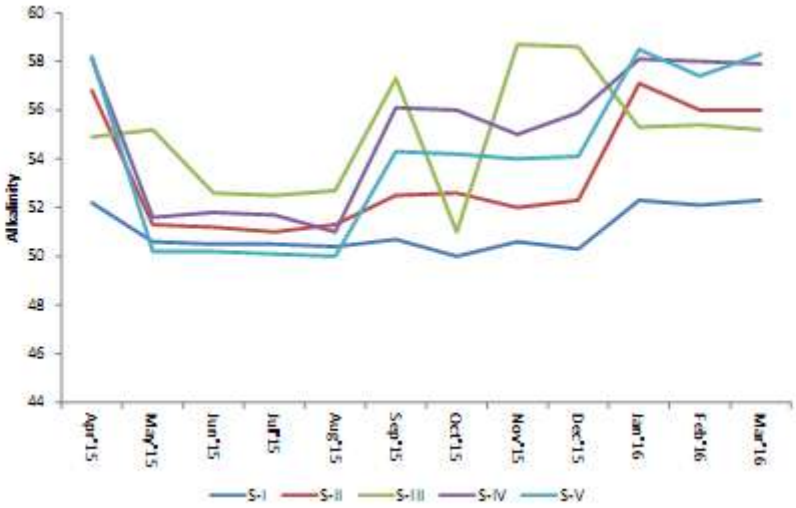

Fig-9: Alkalinity fluctuations at various study sites in Dikhu river

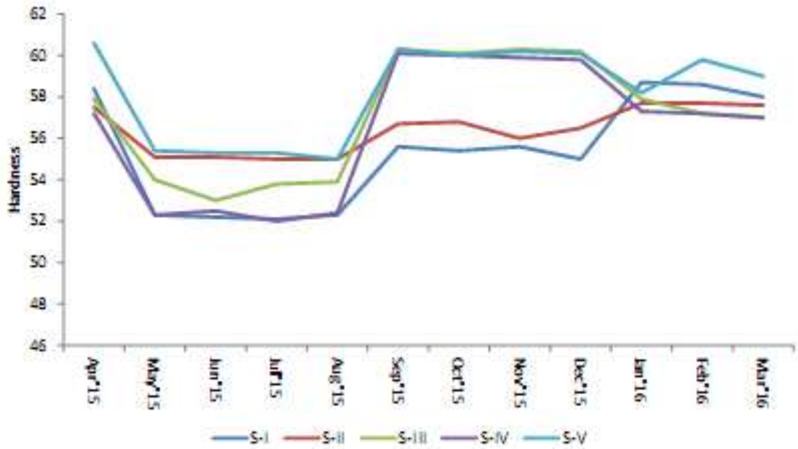

Fig-10: Hardness fluctuations at various study sites in Dikhu river

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