ORIGINAL RESEARCH ARTICLE

PHYSICO-CHEMICAL PARAMETERS OF RIVER SIANG IN ARUNACHAL PRADESH, INDIA

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ABSTRACT:

Water is one of the nature's most important gifts to mankind. River Siang is the main river of East Siang district and also it is one of the most important influent tributary of the mighty River Brahmaputra drainage system. River Siang plays an important role in lives of the surrounding inhabitants *viz*. fishing, bathing, washing, disposal, industrial wastes, and other human activities. Analysis of physico-chemical parameters were carried out during 2012-2014 in the four different seasons at different study sites of River Siang. The major and important water quality parameters were measured in all collected samples, including Water Colour, Air Temperature, Water Temperature, pH, DO, FCO_2, Conductivity, Total alkalinity, Turbidity, Total Hardness, TSS, TDS.

KEY WORDS: Physico-Chemical Parameters, WHO, East Siang, Arunachal Pradesh

INTRODUCTION:

Among all the natural resources on planet, water is most vital resource. Rivers are vital systems and are essential for the sustenance of all life. The Arunachal Pradesh's territory is a complex hill system with varying elevation, and number of rivers and rivulets [1]. The unique drainage system of the state falls under upper Brahmaputra basins. For domestic, industrial and agricultural purposes rivers provides main water resources [2]. The main sources of pollution of river water are

modern civilization, urbanization and prolonged discharge of industrial effluents, domestic sewage and solid waste dump [3]. Wild and domestic animals using same drinking water can also contaminate the water through direct defection and urination [4]. The environment and the ecosystem were badly affected by social, agricultural and industrial activities of human population. River water and ground water were polluted by the growing use of chemicals in the form of fertilizers and pesticides. The ecosystem could be destabilized and could cause ill effects on the health of the human beings as well as all other living organisms [5], [6]. The physical and chemical characteristics of any riverine water, sediments play an important role of ecological significance especially in river ecosystem. It reflects the history of the pollution.

STUDY SITE:

The River Siang, is largest river of Brahmaputra river system, originates from Chema Yungdung Glacier near Kubi at 5150 m in Tibet. In Tibet it flows in West–East direction. After 1625 km traverse in Tibet it takes a turn in south direction, enters the territory of India near Tuting in the Upper Siang district of Arunachal Pradesh. Then it flows through North–South direction in East Siang district towards Assam. Finally it merges with Lohit and Dibang in Assam and it becomes the mighty River Brahmaputra [7], [8].

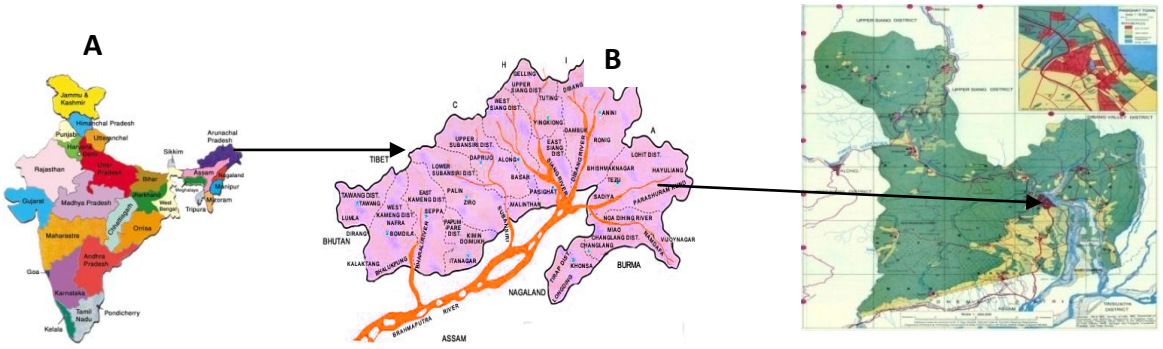


Fig 1: Map of (A) India indicating Arunachal Pradesh, (B) Arunachal Pradesh indicating to East Siang District, (C) In East Siang district highlighting River Siang (Study Area) of Arunachal Pradesh

MATERIALS AND METHODS:

Water was collected and stored in clean polyethylene bottles that have been pre washed with de-ionized water. Air temperature, water temperature and pH

were determined in the field because of their unstable nature. Water temperature and air temperature were measured with the help of mercury thermometer and pH was measured with pen type pH meter in the field and other parameters was analyzed in the laboratory using standard procedure of APHA [9] and using Perkin Elmer Atomic Absorption Spectrophotometer (AAS) [10].

RESULTS:

The present study of physico-chemical parameters of the River Siang revealed the below mentioned parameters and the parameters are discussed in the below:

1. **Water Colour:** The colour of water colour was clear in most of the seasons at the different study sites but sometimes the colour is pale-green in the mid-stream of the river.

Table 1: Physico-Chemical Parameters (Mean and S.D) of River Siang:

Sr. No.	Parameters	Winter	Pre-Monsoon	Monsoon	Post-Monsoon
1	Air Temp.C^0	16.17 ± 1.47	27.17 ± 1.94	36.67 ± 9.87	27.50 ± 1.64
2	Water Temp. C^0	13.50 ± 3.08	24.00 ± 4.05	27.17 ± 1.72	25.33 ± 3.93
3	pH	6.60 ± 0.30	6.83 ± 0.44	6.91 ± 0.19	7.16 ± 0.42
4	DO (mg/l)	5.30 ± 1.15	7.67 ± 0.77	7.97 ± 0.95	6.62 ± 0.27
5	FCO_2(mg/l)	8.47 ± 1.20	4.87 ± 0.86	7.23 ± 1.38	7.92 ± 1.50
6	Conductivity (ppm)	13.83 ± 2.23	13.17 ± 2.04	8.00 ± 2.10	9.33 ± 2.07
7	Total Alkalinity (mg/l)	68.54 ± 5.75	84.47 ± 9.50	69.53 ± 13.83	80.27 ± 9.08
8	Turbidity (NTU)	93.08 ± 6.83	87.79 ± 9.24	82.60 ± 8	89.43 ± 9.86
9	Total Hardness (mg/l)	72.08 ± 3.33	77.13 ± 8.04	96.98 ± 24.57	69.67 ± 3.69
10	TSS (mg/l)	117.48 ± 9.33	120.08 ± 15.72	256.93 ± 3.38	120.87 ± 6.87
11	TDS (ppm)	6.17 ± 1.17	5.17 ± 1.60	5.75 ± 1.89	7.67 ± 2.07

Values Mean ± SD

2. **Air Temperature (AT):** AT (^{0}C) ranges between 22.50 ± 1.38 to 30.17 ± 5, minimum being in winter season and maximum in monsoon season. Test of variance (t-test) for AT (^{0}C) revealed that, the values obtained from t-test ranging from 20.064849 to 30.685151, had been found to be statistically significant (P<0.001, 95% CI) (Table 1 and Figure 3).
3. **Water Temperature (WT):** WT (^{0}C) value ranged between 13.50 ± 3.08 to 27.17 ± 1.72, minimum in winter season and maximum in monsoon season. Test

of variance (t-test) for WT (^{0}C) revealed that, the values obtained from t-test ranging from 12.731758 to 32.268242, had been found to be statistically significant (P<0.005, 95% CI) (Table 1 and Figure 3).

4. **pH:** The pH value ranged between 6.60 ± 0.30 to 7.16 ± 0.42, minimum in winter season and maximum in post-monsoon season. Test of variance (t-test) for pH revealed that, the values obtained from t-test ranging from 6.509343 to 7.238990, had been found to be statistically significant (P<0.001, 95% CI) (Table 1 and Figure 3).
5. **Dissolved Oxygen (DO):** The DO (mg/l) value ranged between 5.30 ± 1.15 to 7.97 ± 0.95, minimum in winter season and maximum in monsoon season. Test of variance (t-test) for DO (mg/l) revealed that, the values obtained from t-test ranging from 4.968067 to 8.806933, had been found to be statistically significant (P<0.001, 95% CI) (Table 1 and Figure 3).
6. **Free Carbon-di-oxide (FCO_2):** The FCO_2 (mg/l) value ranged between 4.87 ± 0.86 to 8.47 ± 1.20, minimum in pre-monsoon season and maximum in winter season. Test of variance (t-test) for FCO_2 (mg/l) revealed that, the values obtained from t-test ranging from 4.598432 to 9.643234, had been found to be statistically significant (P<0.001, 95% CI) (Table 1 and Figure 3).
7. **Conductivity:** The conductivity (µmho/cm) value ranged between 127.67 ± 5.10 to 156.78 ± 7.07 minimum in winter season and maximum in post-monsoon season. Test of variance (t-test) for conductivity (µmho/cm) revealed that, the values obtained from t-test ranging from 123.538613 to 151.628054, had been found to be statistically significant (P<0.001, 95% CI) (Table 1 and Figure 3).
8. **Total Alkalinity (TA):** The TA (mg/l) value ranged between 68.54 ± 5.75 to 84.47 ± 9.50, minimum in winter season and maximum in post-monsoon season. Test of variance (t-test) for TA (mg/l) revealed that, the values obtained from t-test ranging from 63.139870 to 88.264297, had been found to be statistically significant (P<0.001, 95% CI) (Table 1 and Figure 3).
9. **Turbidity:** The turbidity (NTU) value ranged between 82.60 ± 8 to 93.08 ± 6.83, minimum in winter season and maximum in monsoon season. Test of variance (t-test) for turbidity (NTU) revealed that, the values obtained from t-test ranging from 81.296169 to 95.155498, had been found to be statistically significant (P<0.001, 95% CI) (Table 1 and Figure 3).
10. **Total Hardness (TH):** The TH (mg/l) value ranged between 69.67 ± 3.69 to 96.98 ± 24.57, minimum in post-monsoon season and maximum in

monsoon season. Test of variance (t-test) for TH (mg/l) revealed that, the values obtained from t-test ranging from 59.223704 to 98.709629, had been found to be statistically significant (P<0.001, 95% CI) (Table 1 and Figure 3).

11. **Total Suspended Solids (TSS):** The TSS (mg/l) value ranged between 117.48 ± 9.33 to 256.93 ± 3.38, minimum in winter season and maximum in monsoon season. Test of variance (t-test) for TSS (mg/l) revealed that, the values obtained from t-test ranging from 144.456347 to 263.223653, had been found to be statistically not significant (P>0.005, 95% CI) (Table 1 and Figure 3).
12. **Total Dissolved Solids (TDS):** The TDS (ppm) value ranged between 5.17 ± 1.60 to 7.67 ± 2.07, minimum in pre-monsoon season and maximum in post-monsoon season. Test of variance (t-test) for TDS (ppm) revealed that, the values obtained from t-test ranging from 4.488073 to 7.886927, had been found to be statistically significant (P<0.001, 95% CI) (Table 1 and Figure 3).

Correlation matrix analysis of physico-chemical parameters of water:

The statistical analysis had been carried out by Pearson's correlation coefficient between physico-chemical parameters of water of River Siang. A linear association implies that as one variable increases, the other increases or decreases linearly. Values of the correlation coefficient close to 1 (positive correlation) imply that as one variable increases, the other increases nearly linearly. However, a correlation coefficient close to -1 implies that as one variable increases, the other decreases nearly linearly. Values close to 0 imply little linear correlation between the variables or no correlation.

In River Siang, Pearson's correlation of water revealed strong positive and negative correlations among the physico-chemical parameters as showed in Table 2. The strong positive correlation of WT with AT (r = 0.981, significant at 0.05) was due to the relationship of air temperature and water temperature. The strong positive correlation of WT with pH (r = 0.957, significant at 0.05) due to the hydrolysis of ion on surface of water in River Siang. DO showed positive correlation with AT (r = 0.970, significant at 0.05). Hardness showed negative correlations with water temperature (r = -0.967, significant at 0.05) and with pH also (r = -0.998, significant at 0.01). TDS showed positive correlations with turbidity (r = 0.969, significant at 0.05). Conductivity showed positive correlations with TSS (r = 0.993, significant at 0.01).

The positive and negative correlation among all the physico-chemical

parameters was the represented the major sources of seasonal changes in water quality of River Siang (Table 2).

Table 2: Pearson's Correlation for different Physico-Chemical parameters of River Siang during different seasons

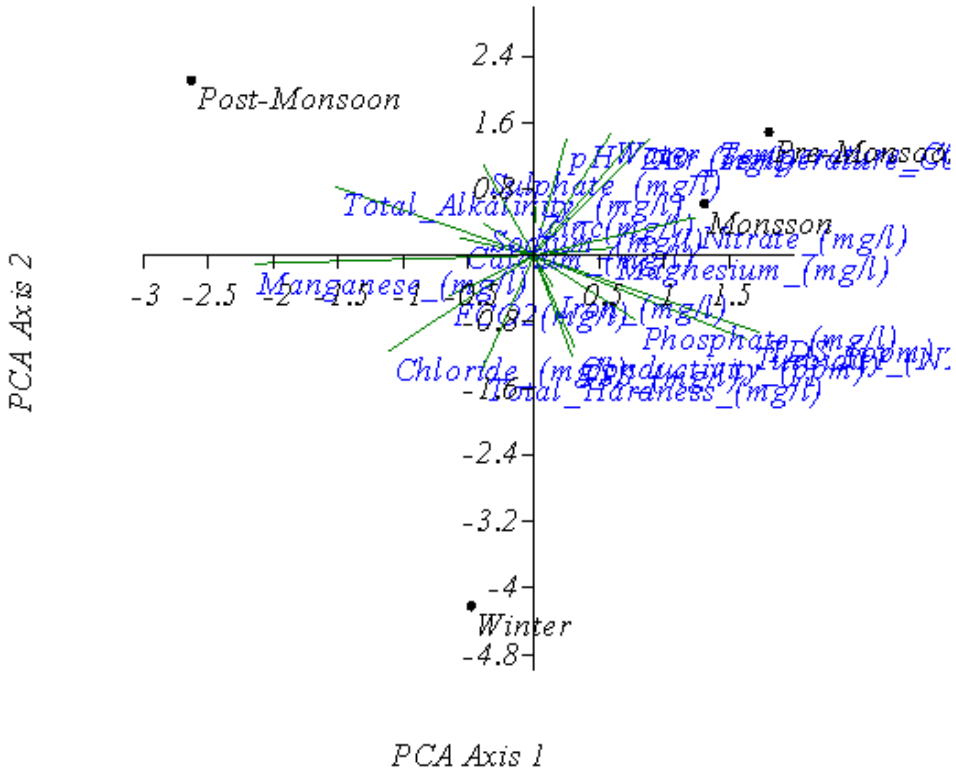
	AT	WT	Turbidity	TSS	pH	DO	FCO_2	TA	TH	TDS	Conductivity
AT	1										
WT	**0.981***	1									
Turbidity	-0.301	-0.444	1								
TSS	-0.672	-0.800	0.696	1							
pH	0.886	**0.957***	-0.566	-0.938	1						
DO	**0.970***	0.927	-0.309	-0.532	0.782	1					
FCO_2	-0.413	-0.266	-0.122	-0.319	0.013	-0.608	1				
TA	0.212	0.262	-0.807	-0.233	0.231	0.362	-0.401	1			
TH	-0.907	**-0.967***	0.508	0.918	**-0.998****	-0.802	0.013	-0.183	1		
TDS	-0.234	-0.350	**0.969***	0.519	-0.422	-0.302	0.062	-0.925	0.364	1	
Conductivity	-0.597	-0.735	0.661	**0.993****	-0.900	-0.437	-0.428	-0.153	0.879	0.467	1

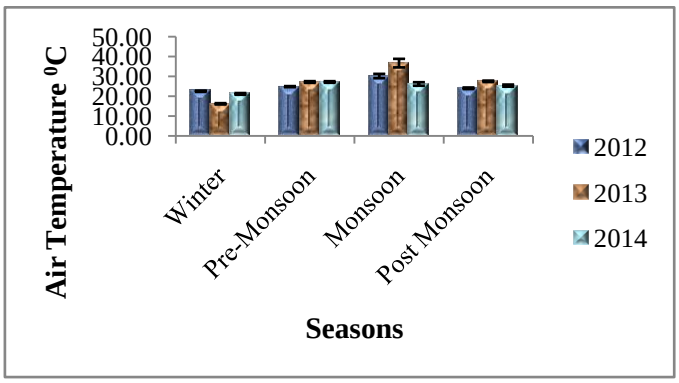
Principal Component Analysis (PCA) of Physico-Chemical Parameters:

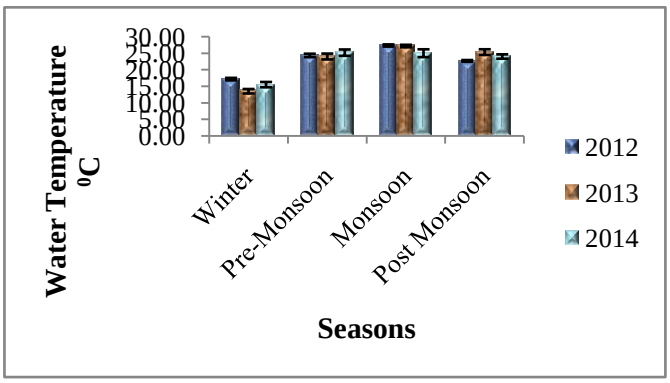
The results obtained from the Principal component analysis (PCA) based on data of different seasons revealed that the variables, notably, temperature, total alkalinity, total hardness, DO and FCO_2 were associated with higher values of communalities during all the seasons. However, other physico-chemical variables

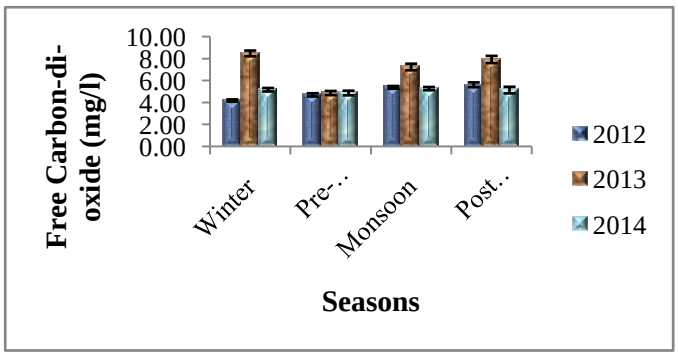
such as pH, conductivity, iron, nitrate, phosphate and zinc had less contribution to the communalities. The two-dimensional PCA ordination with various rotations basically showed a continuous pattern of samples. It was evident from the PCA as represented in Figure 2, that relative distance between the four survey seasons indicates the similarity between them and respective coordinates. The analysis of PCA revealed that, at the level of significance Alpha=0.50, the decision was to reject the null hypothesis of absence of significant correlation. In other words, the correlation between variables was significant.

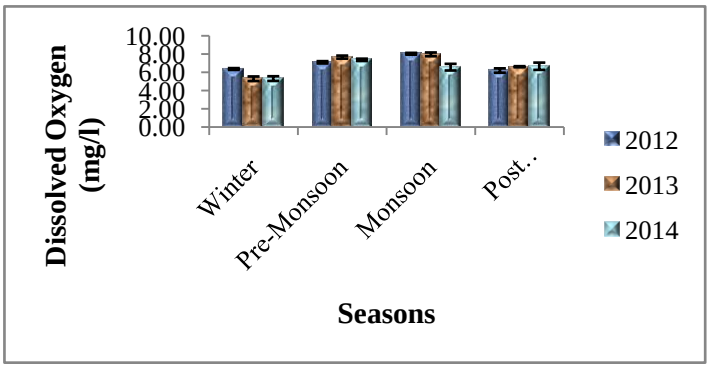
Figure 2: Bi-plot of PCA analysis derived from the four studied seasons on the physico-chemical parameters of River Siang

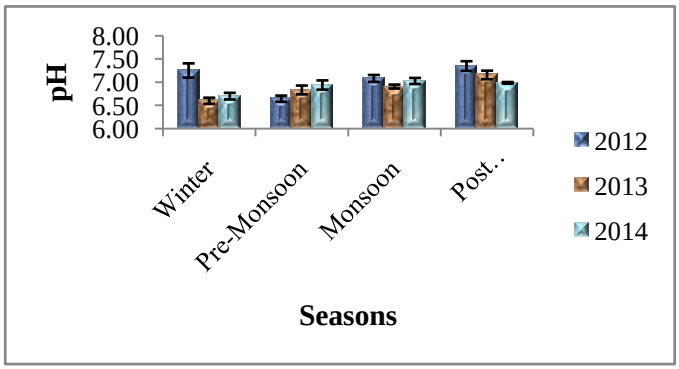


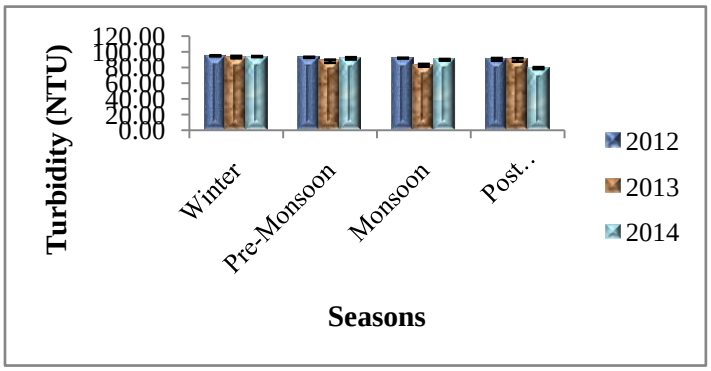

Air Temperature ⁰C
50.00
40.00
30.00
20.00
10.00
0.00
Winter
Pre-Monsoon
Monsoon
Post Monsoon
2012
2013
2014
Seasons

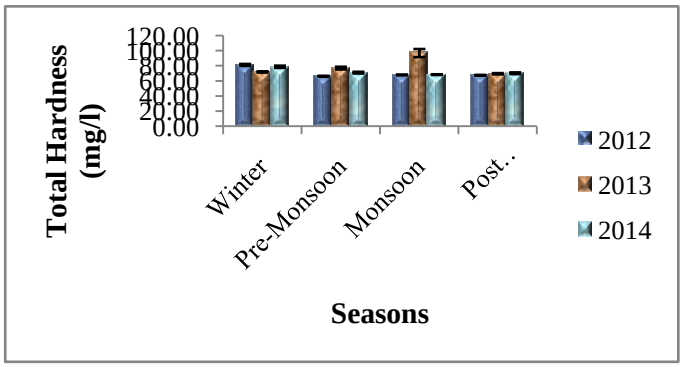

Water Temperature ⁰C
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Winter
Pre-Monsoon
Monsoon
Post Monsoon
2012
2013
2014
Seasons

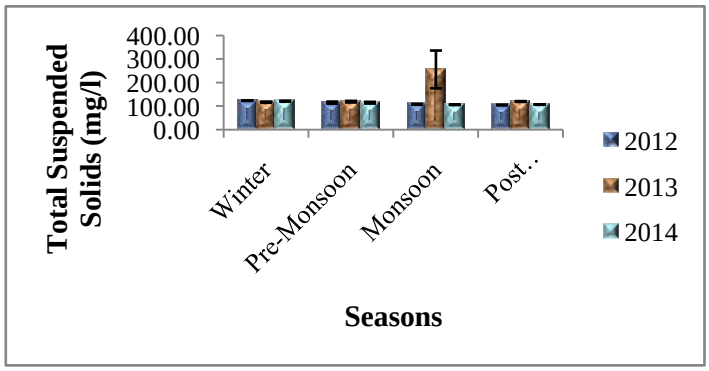

Free Carbon-di-oxide (mg/l)
10.00
8.00
6.00
4.00
2.00
0.00
Winter
Pre-…
Monsoon
Post..
2012
2013
2014
Seasons


Dissolved Oxygen (mg/l)
10.00
8.00
6.00
4.00
2.00
0.00
Winter
Pre-Monsoon
Monsoon
Post..
2012
2013
2014
Seasons


pH
8.00
7.50
7.00
6.50
6.00
Winter
Pre-Monsoon
Monsoon
Post..
2012
2013
2014
Seasons


Turbidity (NTU)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Winter
Pre-Monsoon
Monsoon
Post..
2012
2013
2014
Seasons


Total Hardness (mg/l)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Winter
Pre-Monsoon
Monsoon
Post..
2012
2013
2014
Seasons


Total Suspended Solids (mg/l)
400.00
300.00
200.00
100.00
0.00
Winter
Pre-Monsoon
Monsoon
Post..
2012
2013
2014
Seasons

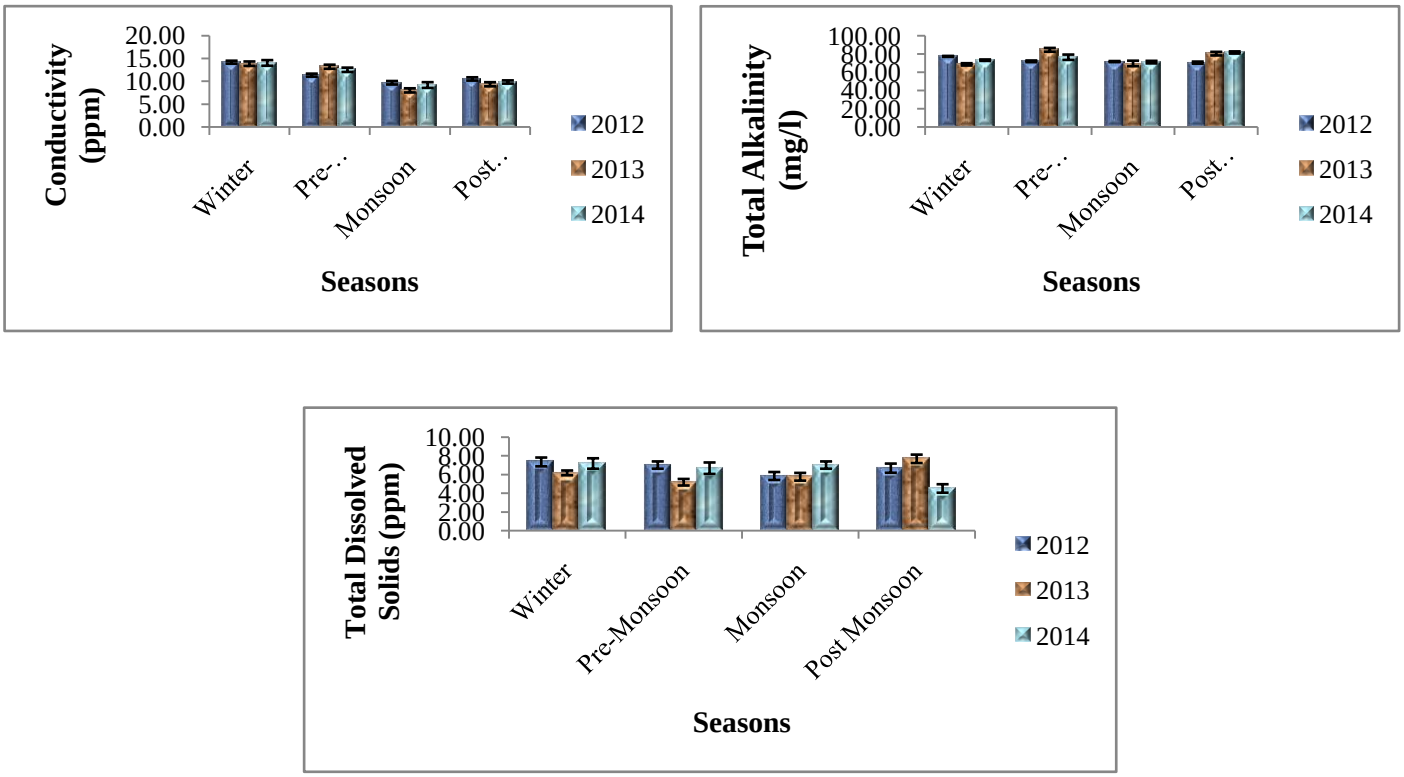


Fig 3: Physico-Chemical Parameters of River Siang in Different Seasons and Year

DISCUSSION:

Physico-chemical characteristics of water varied according to seasons. Most of the water parameters vary seasonally. The air temperature in river water was largely regulated by solar radiation and topography. Temperature, in turn, regulates the dissolved oxygen concentration of water and primary productivity, causes a great variability in plant and animal distribution. Water temperature showed a definite seasonal trend of increased during monsoon season and decreased during the winter seasons. The degree and annual variation in water temperature of a water body had been a great bearing upon its productivity. There was no significance change in the pH value during the whole observation periods. The pH values of the River Siang were under the permissible limit of the WHO for drinking purposes. The maximum DO value in monsoon season, it was because of the bright sunlight as it influences the percentage of soluble gases. The long day period of high intensity of sunlight accelerated photosynthesis which resulted to increase DO in monsoon season. During the present study it was observed that the FCO_2 showed an inverse relationship with DO. The conductivity of River Siang was also affected by the rain water, rain water lowers the conductivity of

River Siang, because rainwater had low conductivity and the increase in water levels dilutes mineral concentrations. The value of total alkalinity of River Siang was under the permissible limit of the WHO standards. Turbidity of the river loses its ability to support aquatic life. Sediments can clog fish gills, reduce growth rate, decrease resistance to disease and prevent egg and larvae development. As particles settle they can smoother the eggs of fish and insects. TSS can also destroy fish habitat because suspended solids settle to the bottom and can eventually blanket the river bed. Suspended solids can smother the eggs of fish and aquatic insects, and can suffocate newly-hatched insect larvae. TDS were recorded maximum in winter season. Seasonally, the values were highest in winter and lowest in monsoon season, the intermediate values were recorded in both pre-monsoon and post-monsoon seasons. The maximum and minimum value of TDS was found to be below the desirable WHO standards limits in River Siang. All the physico-chemical parameters are below the permissible limits of WHO [11] standards.

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