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Variations in water quality characteristics of Serlui river as impacted by Serlui-B hydel project in Kolasib district, Mizoram

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Abstract- The Serlui river is one of the most important natural resource systems in Kolasib district, Mizoram, India. The present study was conducted for a period of one year i.e., from March 2015 to February 2016 to assess the impact of Serlui-B Hydel Project on the water quality of Serlui river, as river water is directly used for drinking and various other domestic purposes by the local people settled in vicinity. Altogether, three sampling sites were selected for detailed investigation along the river from upstream to downstream along the hydel project. The water samples were collected at monthly interval for analysis of various parameters namely, Temperature (22.2˚C-34.3˚C), pH (6.1-7.7), Electrical Conductivity (81µS-154µS), Dissolved Oxygen (5.7-8.1mgL^{-1}), Biological Oxygen Demand (0.6-2.2mgL^{-1}), Acidity (31-68 mgL^{-1} $CaCO_3$), Total Alkalinity (18-70mgL^{-1} $CaCO_3$), Chloride (21-145.67mgL^{-1}$CaCO_3$), Phosphate-P (0.017-0.210mgL^{-1}) and Nitrate-N (0.14-0.60mgL^{-1}). The findings reveal that intensity of pollutants increased from Site 1 (Upstream- Control Site) to Site 3 (Downstream), indicating impact of hydel project on river water quality. It is revealed that values are within the prescribed limits as given by various scientific agencies, except Phosphate-P. But long term use of such water may lead to adverse effects on human beings as well as aquatic life. Thus, there is an ample scope of proper treatment of water before use.

Keywords**:** Pollutants, Serlui-B hydel project, Serlui river, Water quality standards, Water treatment.

I. INTRODUCTION

Water is one of the most essential natural resource of the ecosystem that has many uses inclusive of domestic, industrial, commercial, transportation, recreation and hydroelectric power projects [1]. A great challenge is faced by the world to supply the energy needs of a growing population. Hydropower is one of the ideal options for meeting this challenge but the improper management of water systems may cause serious problems in availability and quality of water [2]. Despite the fact that, the northeastern region has been identified as the future power house of India as it harbors colossal water assets, the ongoing efforts to harness this cosmic hydropower potential through a series of dams has posed an unparalled threat to the water, social and ecological security of the region. Constructions of dam transform landscapes creating a risk of irreversible impact on the environment. Hydropower dams involves the setting up of large infrastructure, which in turns obstruct river flow, transforming the physical and biological characteristics of river channels and floodplains, fragmenting the continuity of rivers [3], environmental degradation, biodiversity reduction [4], leads to deterioration of water quality resulting into nuisance in aquatic environment [5].

The developmental activities of hydel project lead to deteriorate river water quality as well as loss of vegetation and degradation of land in catchment area. Keeping this fact, the present study has been undertaken to critically assess the impact of hydel project on water quality of the Serlui river.

II. MATERIALS AND METHODS

Description of study area and study sites

The Serlui river flows through Kolasib district of Mizoram and is impounded by the Serlui-B Dam, 12 km from Bilkhawthlir Village in the Kolasib district. The Serlui-B has a 293m (961 feet) long, 51m (167 feet) high earthfill embankment dam, a 135m pressure tunnel and a semi-ground power house [6]. The hydel project has 3 units each with a capacity to generate 4MW power. The dam creates a reservoir catchment area of 53 square kilometers with life storage capacity of 453.59 cubic million. The catchment area is 397 square kilometers with an annual rainfall of 3028.6mm [6].

Altogether three sampling sites along the hydel project were selected to study the water quality of Serlui river.

1. **Site 1-** This site is situated at the upstream of the dam with least anthropogenic activities and

maintains its natural flow, and is demarcated as reference (control site).

2. **Site 2-** This is diversion inlet of the river where the flow of the water recedes with the development of the reservoir.
3. **Site 3-** This is diversion outlet situated downstream of river, where the treated river water, after power generation is discharged back into the river.

Analytical methods

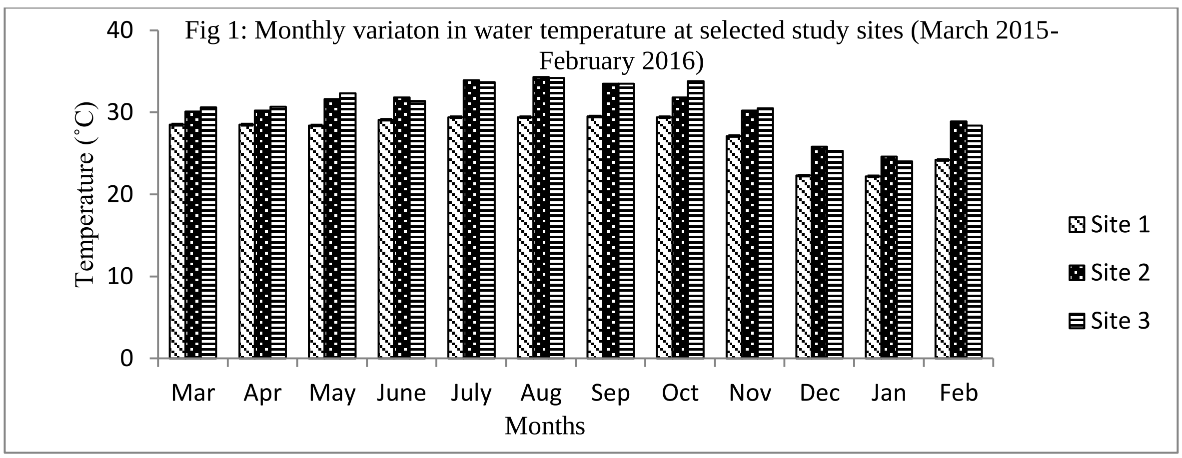
Water samples were collected from selected sites on monthly interval (in triplicates) for one year (March 2015- February 2016). Wide mouth bottles were used to collect the samples with necessary precautions. The water samples were analyzed for various physico-chemical characteristics namely; temperature, pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Acidity, Total Alkalinity, Chloride, Phosphate-P and Nitrate-N following the methods as outlined in the `Standard Methods for Examination of Water and Wastewater` as prescribed by APHA [7] and compared with standards given by as USPH [8], BIS [9], WHO [10]and ICMR [11].

The analysis for the temperature, pH and EC were determined at the place of collection and for analysis of Dissolved Oxygen content, the water samples were fixed immediately after collection. The samples were stored in 4˚C for further analysis. The statistical analyses namely correlation coefficient, standard deviation and standard error were computed to check the validity and significance of data.

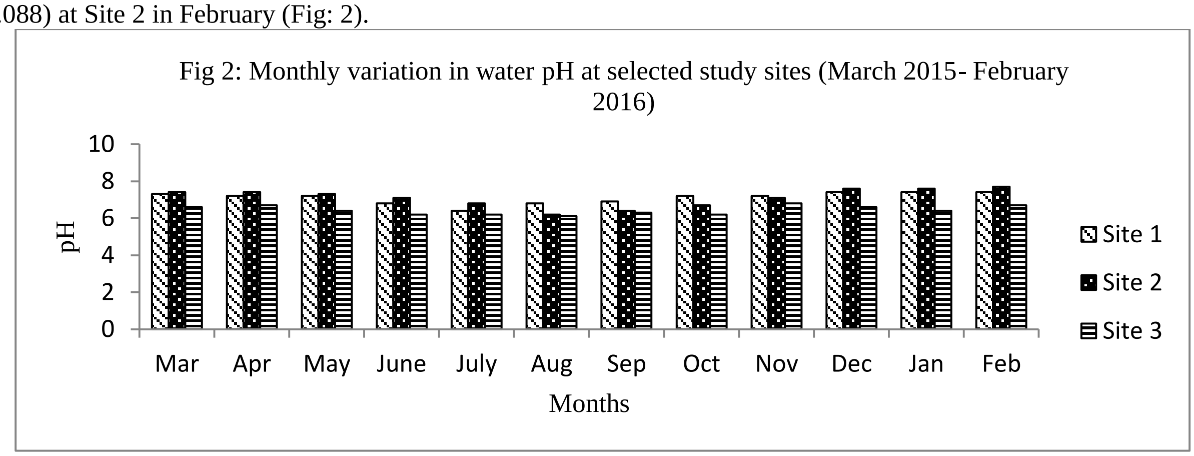
III. RESULTS

The findings on various water quality attributes are presented herewith in Figure 1-10.

A. Temperature: The average temperature was found to be lowest (22.2˚C ±0.67) at Site 1 in the month of January whereas highest value was observed (34.3 ˚C±0.61) at Site 2 in the month of August (Fig: 1).

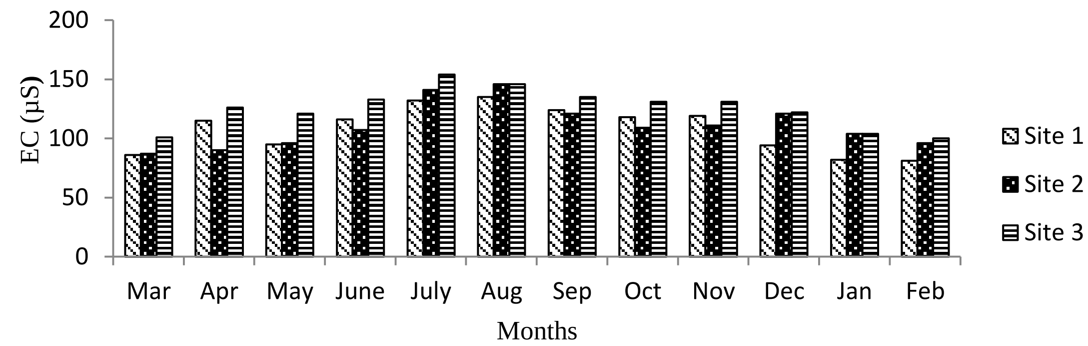


B. pH: The present investigation depicts that the pH was lowest (6.1±0.033) at Site 3 in the month of August and highest (7.7±0.088) at Site 2 in February (Fig: 2).



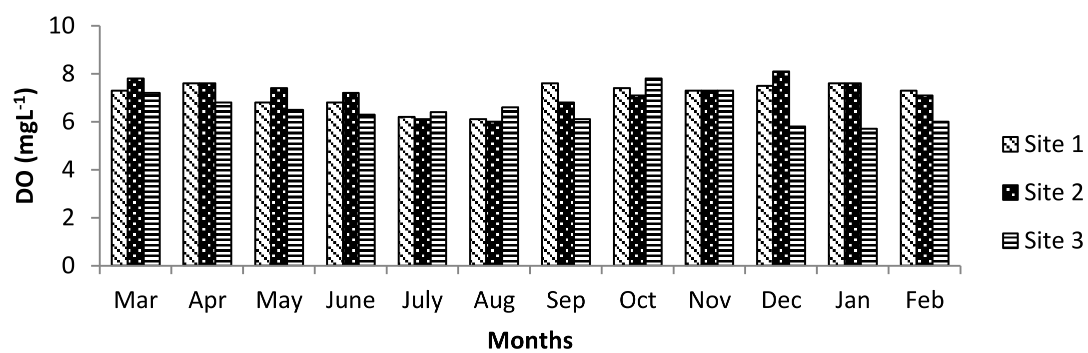
C. Electrical Conductivity (EC): In the present study, the lowest value of EC (81µS±1.155) was recorded at Site 1 in the month of February and the highest value (154µS±2.728) was observed at Site 3 in the month of July (Fig: 3).

Fig 3: Monthly variation in water EC at selected study sites (March 2015- February 2016)



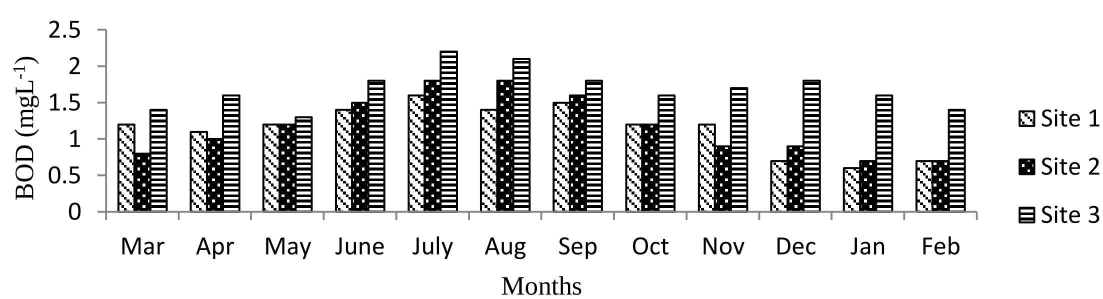
D. Dissolved Oxygen (DO): The DO content was lowest (5.7mgL^{-1}±0.265) at Site 3 in the month of July and highest (8.1mgL^{-1}±0.115) at Site 2 in the month of December (Fig: 4).

Fig 4: Monthly variation in water DO content at selected study sites (March 2015- February 2016)



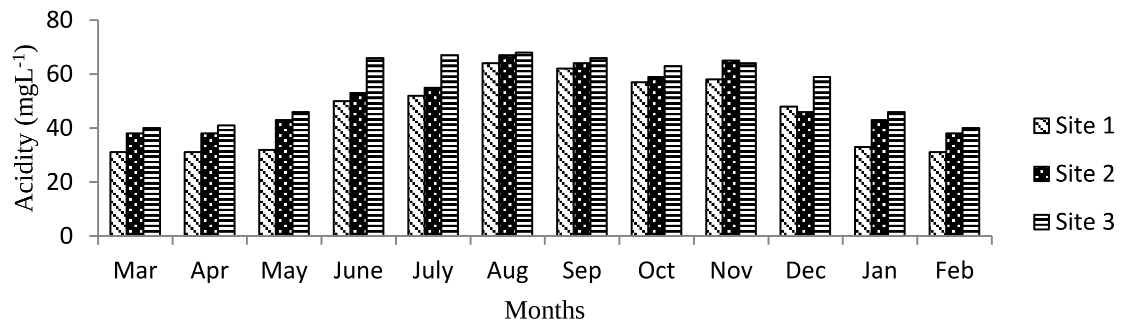
E. Biological Oxygen Demand: The BOD was lowest (0.6mgL^{-1}±0.145) in the month of January at Site 1, on the other hand, highest value (2.2mgL^{-1}±0.115) was seen in Site 3 at the month of July (Fig: 5).

Fig 5: Monthly variation in water BOD content at selected study sites (march 2015- February 2016)



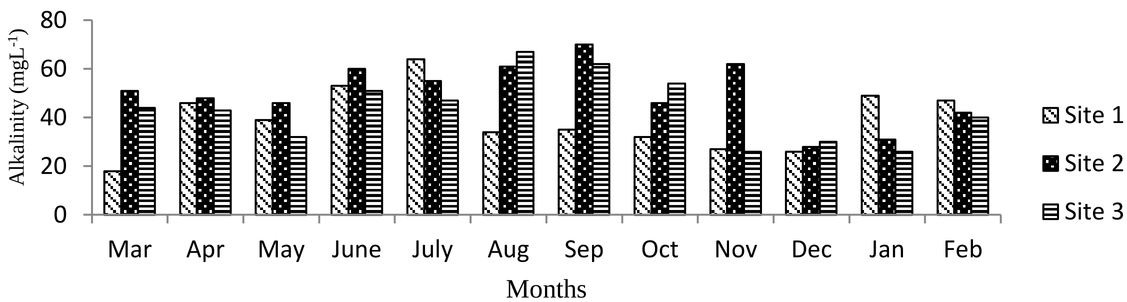
F. Acidity: The present study revealed that lowest value (31mgL^{-1}CaCO$_3$±0.155) was recorded at Site 1 in the month of March and highest value (68mgL^{-1} CaCO$_3$±1.453) was recorded at Site 3 in the month of August (Fig: 6).

Fig 6: Monthly variation in water Acidity at selected study sites (March 2015- February 2016)



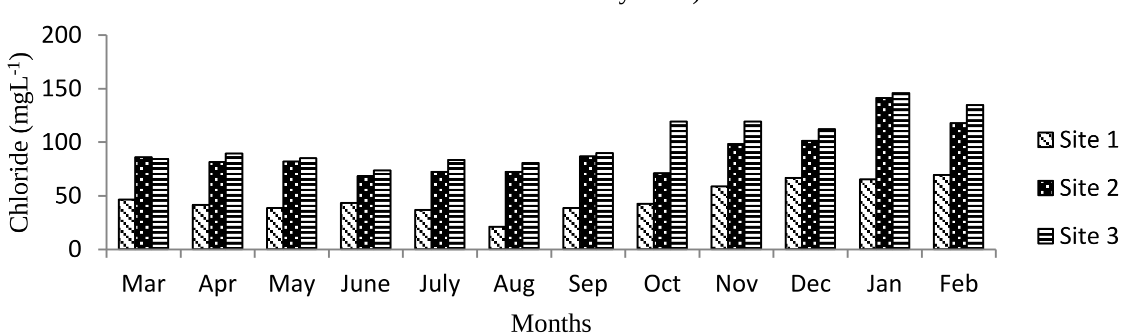
G. Total Alkalinity: The present study revealed that lowest value (18mgL^{-1} CaCO$_3$±1.764) was recorded in the month of March at Site 1 and highest value (70mgL^{-1} CaCO$_3$±1.155) was observed in the month of September at Site 2 (Fig: 7).

Fig 7: Monthly variation in water total Alkalinity at selected study sites (March 2015- February 2016)



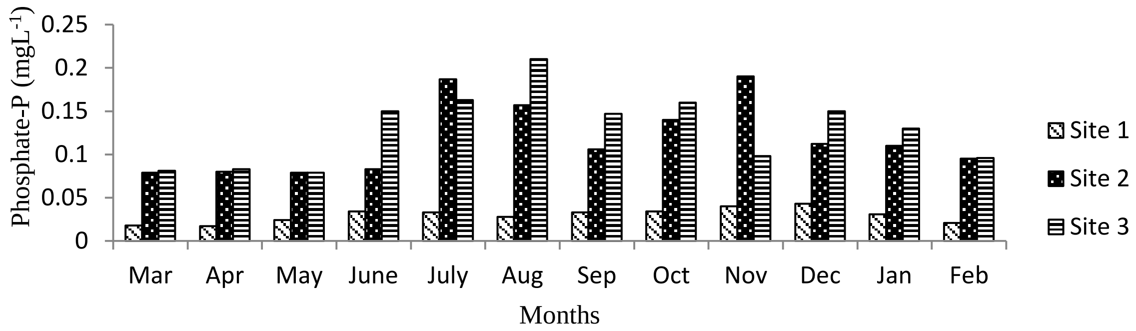
H. Chloride: The lowest value (21.3mgL^{-1} CaCO$_3$±1.453) was recorded at Site 1 in the month of August and highest value (145.67mgL^{-1} CaCO$_3$±2.028) was observed at Site 3 in the month of January (Fig: 8).

Fig 8: Monthly variation in water Chloride content at selected study sites (March 2015- February 2016)



I. Phosphate-P: The lowest value (0.017mgL^{-1}±0.003) was recorded at Site 1 in the month of April and highest value (0.210mgL^{-1}±0.011) was seen at Site 3 in the month of August (Fig: 9).

Fig 9: Monthly variation in water Phosphate-P content at selected study sites (March 2015- February 2016)



J. Nitrate-N: The lowest value (0.14mgL^{-1}±0.015) was recorded at Site 1 in the month of December and highest value (0.60mgL^{-1}±0.018) was observed at Site 3 in the month of July (Fig: 10).

Fig 10: Monthly variation in water Nitrate-N content at selected study sites (March 2015- February 2016)

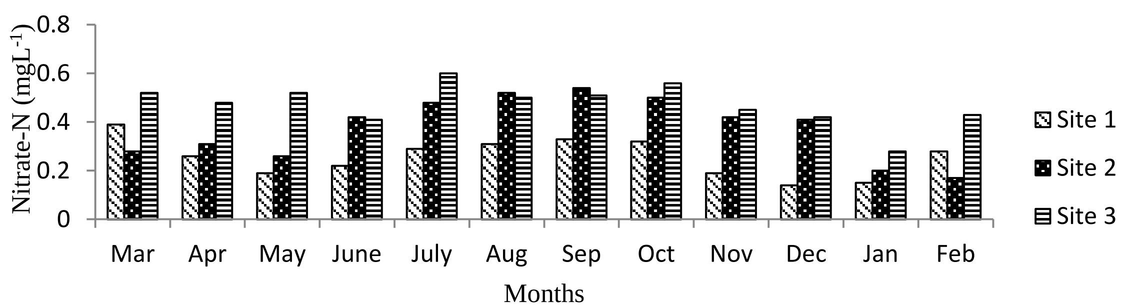


Table 1: Water quality standards given by various scientific agencies and comparison of results

Parameter	Standards				Range of water quality characteristics during the study period
	USPH	BIS	WHO	ICMR	
Temperature (◦C)	-	-	-	-	22.2˚C-34.3 ˚C
pH (nano mole L^{-1})	6 - 8.5	6.5- 8.5	6.5-8.5	7- 8.5	6.1-7.7
EC (µS)	300	-	-	-	81µS-154µS
DO (mgL^{-1})	>4	>5	-	-	5.7mgL^{-1}-8.1mgL^{-1}
BOD (mgL^{-1})	-	<3	-	-	0.6 mgL^{-1}-2.2 mgL^{-1}
Acidity(mgL^{-1} $CaCO_3$)	-	-	-	-	31 mgL^{-1}-68 mgL^{-1}
Total Alkalinity (mgL^{-1} $CaCO_3$)	-	200	-	120	18 mgL^{-1}-70 mgL^{-1}
Chloride(mgL^{-1} $CaCO_3$)	250	250	200	200-1000	21 mgL^{-1}-145.67 mgL^{-1}
Phosphate (mgL^{-1})	0.1	-	-	-	0.017 mgL^{-1}-0.21mgL^{-1}
Nitrate (mgL^{-1})	10	45	10	20	0.14 mgL^{-1}-0.60 mgL^{-1}

- Not available

Table 2: Correlation coefficient between different physico-chemical parameters at Site 1

	Temp	pH	EC	DO	BOD	Acidity	Alkalinity	Chloride	Phosphate	Nitrate
Temp	1									
pH	-0.668	1								
EC	0.719	-0.807*	1							
DO	-0.460	0.750	-0.518	1						
BOD	0.926*	-0.853*	0.816*	-0.580	1					
Acidity	0.399	-0.558	0.801*	-0.333	0.567	1				
Alkalinity	0.046	-0.522	0.189	-0.361	0.139	-0.120	1			
Chloride	-0.871*	0.705	-0.736	0.634	-0.838*	-0.418	-0.085*	1		
Phosphate	-0.221	-0.166	0.302	-0.006	0.034	0.673	-0.074	0.215	1	
Nitrate	-0.572	0.779	-0.758	0.613	-0.697	-0.572	-0.412	0.739	-0.163	1

*- Significant (p> 0.05)

Table 3: Correlation coefficient between different physico-chemical parameters at Site 2

	Temp	pH	EC	DO	BOD	Acidity	Alkalinity	Chloride	Phosphate	Nitrate
Temp	1									
pH	-0.824*	1								
EC	0.444	-0.702	1							
DO	-0.779	0.786	-0.747	1						
BOD	0.842*	-0.853*	0.753	-0.817*	1					
Acidity	0.582	-0.861*	0.737	-0.639	0.665	1				
Alkalinity	0.836*	-0.743	0.314	-0.606	0.656	0.665	1			
Chloride	-0.829*	0.628	-0.292	0.430	-0.724	-0.401	-0.595	1		
Phosphate	0.299	-0.490	0.720	-0.584	0.371	0.711	0.287	-0.126	1	
Nitrate	-0.788	0.599	-0.323	0.556	-0.832*	-0.369	-0.640	0.702	0.045	1

*- Significant (p> 0.05)

Table 4: Correlation coefficient between different physico-chemical parameters at Site 3

	Temp	pH	EC	DO	BOD	Acidity	Alkalinity	Chloride	Phosphate	Nitrate
Temp	1									
pH	-0.523	1								
EC	0.679	-0.587	1							
DO	-0.275	0.419	-0.736	1						
BOD	0.318	-0.543	0.830*	-0.806*	1					
Acidity	0.474	-0.606	0.842*	-0.668	0.797	1				
Alkalinity	0.740	-0.676	0.524	-0.215	0.462	0.468	1			
Chloride	-0.673	0.406	-0.544	0.295	-0.334	-0.294	-0.554	1		
Phosphate	0.287	-0.780	0.656	-0.570	0.818*	0.792	0.612	-0.162	1	
Nitrate	-0.595	0.810	-0.637	0.134	-0.498	-0.626	-0.707	0.326	-0.730	1

*- Significant (p> 0.05)

IV. DISCUSSION

A. Temperature

In the present study it was found that there is a significance increase in the water temperature from Site 1 to Site 3, which may be due to the release of treated water after power generation directly into the river from the dam. An increase in temperature during the rainy months may be due to the discharge of organic matter through surface runoff and subsequently microbial decomposition leading to release of catabolic energy in the form of heat which results into increase of water temperature. Temperature values recorded were within the prescribed limit given by various scientific agencies (Table: 1). The findings of the present study are in conformity with the works of Mishra and Tripathi [12, 13, 14] and Murthuzasab *et al.* [15].

A positive and significant correlation was obtained between temperature with BOD, EC and total Alkalinity in all the study sites. On the contrary, a negative and significant correlation was obtained between temperature with pH, DO and Chloride in all the study sites (Table 2-4).

B. pH

The pH values were found to be slightly acidic during the monsoon season at all the three sites, this may be attributed due to the contamination of water bodies by surface runoff and the high rate of decomposition of organic matter which results into the release of humic acid. pH values recorded were within the prescribed limit given by various scientific agencies (Table: 1). The findings of the present study are in conformity with the works of Saikia and Gupta [16].

A positive and significant correlation was obtained between pH with DO, BOD, Chloride, Nitrate-N and Phosphate-P, on the contrary, a negative and significant correlation was obtained between pH with temperature and EC in all the study sites (Table 2-4).

C. Electrical Conductivity (EC)

The Site 3 showed a higher value of EC, which might be due to the high degree of ionic state as a result of direct discharge of water from the dam after power generation into the water body. Higher EC values during the rainy months and lower during winter maybe attributed to the high concentration of dissolved solids, decomposition and mineralization of organic matters and due to the presence of inorganic materials followed by low ionic state. EC values recorded were within the prescribed given by various scientific agencies (Table: 1) .The findings of the present study are in conformity with the works of Mishra and Tripathi [12, 13, 14] and Singh and Gupta [17].

A positive and significant correlation was obtained between EC with BOD and Acidity, on the contrary, a negative and significant correlation was obtained between EC with DO in all the study sites (Table: 2-4).

D. Dissolved Oxygen (DO)

For the survival of aquatic organisms and maintenance of water bodies, the DO content is of outmost importance [13]. A mark decrease in the DO content was observed from Site1 to Site 3 which maybe due to the consumption of DO in the oxidation of organic materials from the waste discharged at the downstream of the dam indicating a high load of pollution in the water body. Higher value of DO content during winter months maybe due to the decrease in temperature as dissolved oxygen shows an inverse relationship with water temperature therefore, solubility of oxygen increases in water with decrease in temperature. On the contrary, monsoon months shows lower value of DO content in water which could be due to the increased process of microbial decomposition which accelerate the rate of oxygen consumption by oxidizable matter. DO values recorded were within the prescribed given by various scientific agencies (Table: 1) .The findings are in conformity with the work of Rajiv *et al*. [1], Lalparwaii and Mishra [18] and Shivayogimath *et al.* [19].

A positive and significant correlation was obtained between DO with pH, on the contrary, a negative and significant correlation was obtained between DO with BOD in all the study sites (Table: 2-4).

E. Biological Oxygen Demand

The highest value of BOD in the rainy month at Site 3 maybe the result of high concentration of untreated organic waste discharge into the water from the power house outlet resulting into high decomposition rate leading to consumption of more oxygen by the microorganisms. On the other hand, lower values during the winter months at Site 1 maybe the result of low amount of contaminants present at Site 1.The higher values in rainy months might be due to addition of more organic matter from surface runoff leading to an increase in microbial activities at elevated temperature and lower values during winter months might be attributed to low rate of decomposition of organic material. BOD showed a reverse trend in results in comparison with the DO content. BOD values recorded were within the prescribed given by various scientific agencies (Table: 1). Similar trends of results have been reported by Mishra and Tripathi [12, 13] and Lalparmawii and Mishra [18].

A positive and significant correlation was obtained between BOD with temperature, on the contrary, a negative and significant correlation was obtained between BOD with pH, Chloride and Nitrate-N in all the study sites (Table 2-4).

F. Acidity

CO_2 is the main cause of acidity in drinking water. Higher values in Site 3 during the monsoon months maybe due to high organic load supporting decomposition which leads to consumption of oxygen and release of CO_2 by the respiratory activity of the biological organisms. Acidity values recorded were within the prescribed given by various scientific agencies (Table: 1). Similar trend of results were reported by Mishra and Tripathi [12, 13, 14], Shrivastava *et al.* [20] and Singh *et al.* [21].

A positive and significant correlation was obtained between Acidity with EC, BOD and Phosphate, on the contrary, a negative and significant correlation was obtained between Acidity with pH and DO in all the study sites (Table 2-4).

G. Total Alkalinity

Hydroxide, carbonates and bicarbonate are the main cause of alkalinity in water. The higher value of alkalinity in the month of September maybe due to photosynthesis activity of aquatic plants and phytoplanktons. Higher values of alkalinity at Site 2 maybe due to surface runoff, accumulation of organic matter and microbial decomposition in the water body. The total alkalinity values recorded were within the prescribed given by various scientific agencies (Table: 1) .Similar trend of results were reported by Mishra and Tripathi [12, 13, 14] and Singh and Gupta [17].

A positive correlation was obtained between Alkalinity with BOD and Phosphate-P, on the contrary, a negative and significant correlation was obtained between Alkalinity with pH, Chloride and Nitrate-N in all the study sites (Table: 2-4).

H. Chloride

Concentration of chloride serves as an indicator of sewage pollution (Shrivastava *et al.,* 2012). Increase in the content of Chloride from Site 1 to Site 3 maybe due to the release of chloride rich effluent of sewage from the dam outlet. An increase in chloride content during winter months maybe due to the decrease in water level. Lower values during the rainy months may be due to dilution of water with rain. Chloride values recorded were within the permissible limit given by various scientific agencies (Table: 1). Mishra and Tripathi [12, 13, 14] and Singh and Gupta [17] also reported a similar trend of results.

A positive and significant correlation was obtained between Chloride with pH and Nitrate-N, on the contrary, a negative and significant correlation was obtained between Chloride with temperature, EC and BOD in all the study sites (Table: 2-4).

I. Phosphate-P

Higher values of phosphate-P at Site 3 maybe due to the discharge of contaminated waste water containing decayed organic matter. Higher value of Phosphate-P during rainy months maybe due to anthropogenic activities and discharge of waste through runoff containing phosphorus and sediments. The recorded values were higher than the permissible limit given by scientific agencies (Table: 1). Similar trend of results has been reported by Shrivastava *et al.* [20] and Singh *et al*. [21].

A positive and significant correlation was obtained between Phosphate-P with BOD at Site 3 and a positive correlation was observed with Acidity and EC, on the contrary, a negative correlation was obtained between Phosphate-P with DO in all the study sites (Table: 2-4).

J. Nitrate-N

Higher value at Site 3 during monsoon months could be attributed to discharge of treated water containing more organic load from the power house resulting into high rate of decomposition. All the recorded values were within the permissible limit given by scientific agencies (Table: 1). Mishra and Tripathi [12, 13, 14], Shrivastava *et al.* [20] and Banerjee and Gupta [22], also reported a similar trend of results.

A positive and significant correlation was obtained between Nitrate -N with pH, DO and Chloride, on the contrary, a negative and significant correlation was obtained between Nitrate-N with temperature, EC, Acidity, Alkalinity and Phosphate-P in all the study sites (Table 2-4).

V. CONCLUSION

The present study was conducted to assess the impact of Serlui-B hydel project on the water quality of Serlui river as the river water is used directly for drinking and various other domestic purposes by the local people settled in vicinity of the hydel project without any treatment. The findings show that there is a mark increase in the intensity of pollutants from Site 1(upstream-control site) to Site 3 (diversion outlet), therefore, leading to deterioration of river water quality. A marked seasonal variation was also observed in the physico-chemical characteristics during the study. A decrease in water pH was marked from upstream to downstream of the river indicating slightly acidic nature of the river water. A sharp increase in the values of Temperature, EC, BOD, Acidity, Total Alkalinity, Chloride, Phosphate-P and Nitrate-N was observed from Site 1 to Site 3 of the river, on the contrary, a mark decrease in the DO content was recorded from upstream to downstream of the river which maybe due to the discharge of treated water after power generation from the power house outlet directly into the river without any proper treatment and addition of sewage containing more organic load. Increase in BOD content is an indicative of increasing pollution in water bodies. During the study period, although, most of parameters showed the values within the prescribed limit in each season as given by various scientific agencies, the Phosphate-P values recorded were higher than the permissible limit as given by USPH. Phosphate-P is an essential plant nutrient in low concentration, but when it is excess in combination with nitrate-N, it leads to algal bloom Singh *et al*. [20]. High phosphate-P content maybe attributed to agricultural run-off containing phosphate fertilizers caused by heavy rain and sewage influx as waste water tends to increase phosphate-P concentration in water. Even though most of the parameters are within the permissible limits, but, prior to its usage, its proper treatment is of outmost importance as long term use of such water may adversely affect the lives of human as well as aquatic lives. Therefore, it can be concluded that the Serlui-B hydel project has impart a significant negative impact on the water quality. Hence, there is an urgent need of appropriate management measures for sustainable management. Effluent from the power house outlet should be treated before its discharge into the natural water system to restore its quality throughout its length. The findings of present study may be a base line for further studies on maintenance of water quality of river Serlui from the severity of the hydel project through formulating appropriate management strategies.

VI. ACKNOWLEDGEMENTS

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REFERENCES

[1]. Rajiv P., Salam H.A., Kamaraj M., Sivaraj R., Shankar, A., "*Physico Chemical and Microbial Analysis of Different River Waters in Western Tamil Nadu, India*", I Res. J. Environment Sci., Vol.1, Issue.1, pp.2-6, 2012.

[2]. Subba Rao C., SubbaRao N.V., *"Ground water quality in residential colony", Ind. J. Environ. Hlth*., Vol. 37, Issue.4, pp.295-300, 1995.

[3]. Bednarek A. T., *"Undamming Rivers: A Review of the Ecological Impacts of Dam Removal*", Environmental Management., Vol.27, Issue.6, pp.803-81, 2001.

[4]. Zhang Y., Xia J., Liang. T, Shao Q., "*Impact ofWater Projects on River Flow Regimes and Water Quality in Huai River Basin*", Water Resour. Manage., Vol.24, Issue.5, pp.889-908, 2010.

[5]. Sunar. S., Mishra B.P., "*Assessing the impact of Hydroelectric Power Project on the water quality of Serlui River in Kolasib district, Mizoram, North-East India*", Int.Res. J. Environment Sci., Vol.5, Issue.9, pp.40-44. 2016.

[6]. PHE., "*Department of Public Health Engineering*", Bilkhawthlir, Kolasib, Mizoram, pp.1-46, 2012.

[7]. APHA., "*Standard methods for the examination of water and waste water"*, 21st edition as prescribed by American Public Health Association (American Water Works Association and Water Environment Federation), Washington, pp.387-388, 2005.

[8]. USPH., *"Drinking Water Standards*", P.H.S. Pub. U.S. Department of Health, Education and Welfare, Washington, pp, 965-978, 1962.

[9]. BIS., "Manual for Specifications for Drinking Water", BIS, India, pp.23-56, 1983.

[10]. WHO., *"Guidelines for drinking water quality*", World Health Organization 3rd Edition, Switzerland, PP.1-515, 2004.

[11]. ICMR., "*Guidelines for Drinking Water Manual*", New Delhi: Indian Council of Medical Research, India, pp.456-463, 1996.

[12]. Mishra B.P., Tripathi B.D., "*Sewage quality analysis: Pollutants removal efficiency of a sewage treatment plant*", J.Ind. Pollut. Contr., Vol.16, Issue.2, pp.239-251, 2000.

[13]. Mishra B.P., Tripathi B.D., "*Impact of city sewage discharge in physico-chemical characteristics of river Ganga water*", Asian J. Micro, Biotech and Env. Sc., Vol.3, Issue.4, pp.333-338, 2001.

[14]. Mishra B.P., Tripathi B.D., "*Seasonal variation in physico-chemical characteristics of Ganga water as influenced by sewage discharge",* Indian J. Ecol.,Vol.30, Isssue.1, pp.27-32, 2003.

[15]. Murthuzasab M.R., Rajashekar M., Vijaykumar K., Haliked N.S., *"Seasonal variation in physicochemical parameters of Hirahalla reservoir Koppa district Karnataka*", Inter. J. Sys. Biol., Vol.2, Issue.2, pp.16-20, 2010.

[16]. Saikia K.C, Gupta S, "*Assessment of surface water quality in an arsenic contaminated village",* American Journal of Environmental Science, Vol.8, Issue.5, pp.523-527, 2012.

[17]. Singh M.R., Gupta A., "*Seasonal variation in certain physico-chemical parameters of Imphal, Iril and Thoubal rivers from Manipur river system, India*", Ecology, Environment and Conservation., Vol.16, Issue.2, pp.197-207, 2010.

[18]. Lalparmawii S., Mishra B.P., *"Seasonal variation in water quality of Tuirial River in vicinity of the hydel project in Mizoram*, India", Sci Vision., Vol.12, Issue.4, pp.159-163, 2012.

[19]. Shivayogimath C.B., Kalburgi P.B., Deshannavar U.B., Virupakshaiah D.B.M., *"Water Quality Evaluation of River Ghataprabha, India",* India. I Res. J. Environment Sci., Vol.1, Issue.1, pp.12-18, 2012.

[20]. Shrivastava N., Mishra D.D., Thakre G., "*Water quality assessment with reference to Machna river, Betul (M.P) India*", Poll. Res. Vol.29, Issue.2, pp.371-374, 2010.

[21]. Singh M.R., Gupta A., Beeteswari K.H., "*Physicochemical properties of water samples from Manipur river system India",* J. Appl. Sci. Environ. Manage, Vol.14, Issue.4, pp.85-89, 2010.

[22]. Banerjee U.S., Gupta S., "*Seasonal assessment of irrigation water suitability of river Damodar in West Bengal India*", J. Crops and Weeds, Vol.6, Issue.1, pp.6-12, 2010.

