Temporal Variation in Water Quality of Dhansiri River, North East India

Wati Iemla, Maibam Romeo Singh and Khikeya Semy[1]

Department of Botany, Nagaland University, Lumami-798 627, India
[1]Department of Botany, New Model College, Wakching-798 622, India
E-mail: watilemm@gmail.com

Abstract: This study focused on understanding how various activities throughout the year affect water quality and contribute to seasonal fluctuations. Three sampling stations were selected for the study, and sixteen physicochemical parameters of water variables were investigated from February 2021 to January 2022. Turbidity in all seasons and TA in winter exceeded the World Health Organizations (WHO 2017) and Bureau of Indian Standards (BIS 2012) drinking water permissible limits. There was significant relationship existing among the sixteen parameters.

Keywords: Dhansiri river, Physicochemical parameters, Permissible limits, Anthropogenic activities, Variable, Correlations

Water is the most abundant natural resource and a prerequisite for all living beings. It is available as surface water (rivers, streams, ponds, and natural springs) and sub-surface water (groundwater). Among all the sources, rivers play a crucial role in sustaining livelihood and maintaining various sectors of the economy by providing water supply for drinking and industrial purposes, irrigation, hydropower generation, tourism, infrastructure, and recreational activities (Venkatramanan et al 2014). However, these rivers are continuously being tainted by extensive growth of urbanization and industrial activities, generating large amounts of solid and liquid waste in urban areas and leading to physical, chemical and microbial contamination of river water. The Ganga River near Kanpur was reported by Trivedi et al (2009) to be quite turbid, and significant relationship between total alkalinity and Cl^-, Mg^{2+}, Ca^{2+}, and TDS. In contrast, the Himalayan rivers were discovered to be degrading due to eutrophication, tourism, geogenic and anthropogenic factors (Seth et al 2016). Various workers, like Nandal et al (2020) and Rahman et al (2021), reported on water pollution load, stating that industrial discharge and toxicological substances have adversely affected the river. Sarmah et al (2020) concluded that anthropogenic activities are the cause of the decline in water quality. Thus, considering the importance of water, it is imperative to know the status of river water and the activities impacting their quality.

The Dhansiri, with a total catchment area of 1,220 square km is a major river of Chümoukedima and Dimapur district of Nagaland. It flows through 352 km from south to north before joining the Brahmaputra on its south bank. Indigenous populations living along the riverbank rely solely on this river for daily household needs. However, it is subjected to tremendous pressure and is susceptible to contamination by both natural and man-made factors. Furthermore, there are no records of seasonal studies on this river, necessitating water quality monitoring and assessment. Therefore, the objective of this research is to examine the spatiotemporal variation in the river's physicochemical qualities along the stretch of the river, as well as to determine the state of water quality and its usability for the community that relies on it.

MATERIAL AND METHODS

Study area: Following a thorough assessment of the study area, three sampling sites were chosen for the Dhansiri River water quality investigation. The activities along the riverbed and the pollutants entering the river were considered when selecting the research areas; GPS coordinates and characteristics of sampling points were distributed as follows (Table 2).

Sampling and analysis: Water samples were collected for a period of 12 months covering the four seasons: winter (December-February), spring (March-May), summer (June-august), and autumn (September-November) from 2021 to 2022. Approximate 10-20 cm depth was considered for the water sample collection. It was stored in a pre-cleaned plastic bottle, appropriately labelled, and taken to the laboratory in an ice box for subsequent analysis. The sampling, preservation, and transportation were done following standard sampling methods (APHA 1998). Physicochemical analysis of 16 water parameters was done using standard method (Trivedi and Goel 1986, APHA 2012). Pearson

correlation matrix among the water parameters was estimated using statistical software SPSS version 16.0.

RESULTS AND DISCUSSION

The seasonal values of the sixteen physicochemical parameters are depicted in Table 3.

pH: The average pH of the three sites ranged from 7.82-8.07 (winter), 7.65-7.76 (spring), 7.33-7.42 (summer), and 7.41-7.47 (autumn). The seasonal pH study shows a maximum in the winter at SS1, and minimum at SS2 in the summer. Hussain et al (2021) noticed the similar tendency, stating that alkaline pH is caused mostly by carbonate production, microbial respiration at high temperatures, and organic waste deposition during rainfall.

Water temperature: The temperature of river water is dependent on the interaction with environmental factors (Hussain et al 2021). During summer, due to a rise in the atmospheric temperature, the WT was at its maximum, ranging from 29.87°C (SS2) to 30.25°C (SS1) in summer. Meanwhile, with the change in the seasonal pattern of the region, the WT drops to 22.97°C (SS2) to 23.08 °C (SS1) in winter.

Total dissolved solids: TDS estimates the amount of organic and inorganic particles in the water sample and displays the quality attributes. The lowest TDS value was recorded in SS2 during winter and highest in summer at all stations; sand mining is common in all three stations, especially in summer. The elevated level of TDS is due to the weathering of rock and the increased flow rate of river water, which causes soil erosion and resuspension of riverbed sediments (Effendi et al 2015).

Electrical conductivity: EC measures the capacity of a solution to carry electrical current and indicates the concentration of dissolved ions present in the water. Seasonally, the EC value was recorded highest and lowest in summer (193.38 µS/cm) and winter (124±11.66 µS/cm) at SS2.

Turbidity: The observed mean value of turbidity in winter (8.82-22.62 NTU), spring (14.15-30.03 NTU), summer (29.54-44.67 NTU), and autumn (23.85-33.80 NTU) were within the permissible limit of BIS/WHO. The mixing of suspended particles and activities, including sand mining, recreational fishing, washing, and irrigation, are responsible for the high turbidity level in all the sites.

Table 1. Water parameters and its analytical methods

Parameters	Unit	Method
pH		Potentiometric portable digital meter (HM Digital pH- 80)
Water Temperature (WT)	°C	Thermometer
Total Dissolve Solids (TDS)	mg/l	Gravimetric
Electrical Conductivity (EC)	µS/cm	Electrometric method (Portable digital meter)
Turbidity	NTU	Nephelometric method
Chloride (Cl^-)	mg/l	Titrimetric method (Argentometric method using silver nitrate)
Total Hardness (TH)	mg/l	Titrimetric method (standard solution of EDTA)
Total Alkalinity (TA)	mg/l	Titrimetric method (using indicator methyl orange and phenolphthalein
Dissolve Oxygen (DO)	mg/l	Winkler's titrimetric method
Biological Oxygen Demand (BOD)	mg/l	Winkler's titrimetric method (20°C 5 days incubation)
Potassium (K^+)	mg/l	Flame photometer
Sulphate (SO_4^{2-})	mg/l	Spectrophotometric (Turbidimetry)
Nitrate nitrogen (NO_3^-)	mg/l	Spectrophotometric (Brucine)
Inorganic Phosphorus (PO_4^{3-})	mg/l	Spectrophotometric (colorimetric)

APHA (2012) and Trivedi and Goel (1986)

Table 2. Description of the three sampling sites and coordinates

Sampling station	GPS Coordinates	Brief description of sampling points
Chümoukedima (SS1)	25º45′20"N 93º34′37"E	Recreational activities, plastic and food waste from picnics, chemicals fertilizers and pesticides used in agriculture and sand mining.
Dimapur (SS2)	25º55′14"N 93º44′54"E	Domestic sewage, drainage connections from hospitals and food factories, machinery activities, laundry, washing utensils, and bathing.
Karbi Anglong (SS3)	26º13′06"N 93º50′57"E	Suspended particles from cement factory and brick kilns, debris from religious ritual and oil leakage and urban effluents.

Table 3. Seasonal variation in the physicochemical properties of the three sampling stations of Dhansiri river

Parameters	Winter			Spring			Summer			Autumn			Permissible limits		
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	Range	BIS	WHO
pH	8.1±0.10	7.8±0.05	7.9±0.18	7.7±0.13	7.7±0.13	7.8±0.10	7.3±0.10	7.3±0.15	7.4±0.08	7.7±0.22	7.4±0.21	7.4±0.27	8.1-7.33	6.5-8.5	6.5-8.5
WT (ºC)	23.1±1.43	22.9±1.52	23.1±1.73	27.1±0.69	27.1±0.7	27±0.76	30.2±0.48	29.9±0.57	29.7±0.48	28.3±1.21	28.7±0.99	28.1±1.09	22.9-30.2	NA	NA
TDS (mg/l)	72.78±8.7	71.60±6	81.9±3.99	82.8±11.5	82.8±11.5	84.7±6.90	109.1±11.2	119.4±5.54	124.9±10.3	108.6±9.8	96.3±12.23	117.2±9.7	71.6-124.9	500	600
EC (µS/cm)	126.8±10.9	124.6±11.7	164.6±7.8	147.9±14.7	147.9±14.4	164.4±10	178.5±11.4	193.4±7.76	186±9.84	164.6±9.7	167.1±10.3	161.5±12	124.6-193.4	NA	NA
Turbidity (NTU)	8.8±0.58	22.6±1.33	22.4±1.32	14.1±1.77	14±1.77	30±2.26	29.5±4.74	42.1±4.21	44.7±4.40	23.8±5.29	31.1±3.94	33.8±6.03	8.8-44.7	5	5
Cl^- (mg/l)	9.5±0.82	13.7±0.82	11.8±1.64	14±1.77	14±1.77	19.5±4.23	19.9±2.84	21.2±2.85	21.8±3.28	12.8±2.42	16.1±3.28	12.2±4.39	9.5-21.8	250	250
TH (mg/l)	111.7±7.51	106.1±9.87	109.1±7.87	86.5±8.98	86.5±8.98	82.9±10	52.9±6.73	57±2.85	60.7±8.54	73.6±13.2	65.7±1.37	76.9±8.52	52.9-109.1	200	200
TA (mg/l)	124.6±5.51	114.4±6.68	132.5±10.5	105.5±8.56	105.5±8.56	118.3±5.7	73.9±13.04	77.3±2.43	82.8±9.43	76.2±8.46	89.6±7.79	91.8±10.3	73.9-132.5	120	200
Ca^{2+} (mg/l)	19.5±3.24	19.5±2.01	17.4±2.45	11.2±3.67	11.2±3.67	13.1±2.45	9.6±1.38	10.2±1.68	9.6±1.6	12.8±4.16	13.6±2.12	13.1±1.67	9.6-19.5	75	75
Mg^{2+} (mg/l)	15.3±1.01	14.6±0.84	15.1±1.29	9.9±4.42	9.9±4.42	11.2±3	6.7±1.22	7.8±0.97	8.1±0.74	7.3±1.46	7.6±3.25	7.5±2.94	6.7-15.3	30	50
DO (mg/l)	7.9±0.61	8.6±1.52	7.1±0.60	6.4±1.06	6.4±1.06	6.9±1.29	5.6±1.13	5±0.35	5.3±0.42	8.3±0.61	7.6±1.06	7.4±0.23	5-8.59	5	NA
BOD (mg/l)	4.5±0.31	5.3±0.51	4.3±0.28	3.1±0.61	3.1±0.61	3.6±0.08	3.4±1.25	2.8±0.52	3.1±0.21	3.5±0.17	3.7±0.34	3.9±0.23	2.8-5.3	5	5
K^+ (mg/l)	2.9±0.77	3.6±0.42	3.1±0.76	4±0.87	4±0.87	4.5±0.52	6.1±0.19	6.1±0.44	6.6±1.01	4.1±0.71	4±0.27	4.4±0.41	2.9-6.6	NA	NA
SO_4^{2-} (mg/l)	7.9±0.74	9.9±0.47	10.3±0.51	8.7±1.01	8.7±1.01	11.4±0.96	11.2±0.79	15.6±1.19	14.3±1.11	10.1±0.19	11.7±1.57	12.4±0.66	7.9-15.6	200	250
NO_3^- (mg/l)	0.05±0.03	0.14±0.04	0.2±0.01	0.1±0.08	0.1±0.08	0.3±0.09	0.3±0.09	0.5±0.06	0.5±0.09	0.2±0.09	0.3±0.07	0.3±0.06	0.05-0.5	45	50
PO_4^{2-} (mg/l)	0.14±0.02	0.15±0.03	0.2±0.05	0.2±0.03	0.2±0.03	0.2±0.03	0.2±0.05	0.2±0.02	0.3±0.07	0.2±0.07	0.2±0.02	0.2±0.06	0.1-0.3	NA	NA

Chloride: Chloride is naturally available in all types of water, and when it is present in high concentrations, it is considered an indicator of organic, inorganic, and industrial pollution (Das and Semy 2023). The presence of high value of chloride in water is harmful to irrigation and aquatic life (Venkatesharaju et al 2010). Among all the seasons, Cl⁻ was highest in SS3 during summer (21.77 mg/l) and least at SS1 in winter (9.47 mg/l). During summer, the raised value of chloride in river water may be due to rainwater washing off municipal sewages and domestic waste into the river (Singh and Shrivastava 2015).

Hardness: Most freshwaters primarily contain calcium and magnesium ions (Kumar et al 2011). The observed values of TH in the three stations ranged from 52.88-111.46 mg/l. The seasonal Mg^{2+} and Ca^{2+} level in SS1, SS2 and SS3 ranged from 6.66-15.27 mg/l and 9.62-19.5 mg/l, respectively. The results of the seasonal analysis of the parameters TH, Ca^{2+}, and Mg^{2+} revealed that the highest levels were seen in the winter and the lowest during the summer, and that the values obtained were within the acceptable range of the BIS/WHO standard.

Total alkalinity: Alkalinity in water is due to carbonates, bicarbonates, or hydroxides from limestone, salts, dissolved rocks, and sediments (Kumar et al 2012). The average TA value obtained from all the sampling stations during the four seasons ranged from 73.95-132.50 mg/l. TA exceeded desirable limit of BIS/WHO during the winter. The value decreased in the summer and autumn, which according to Singh et al (2004) is caused due to excessive dilution by rain water.

Dissolved oxygen: It measures oxygen dissolved in water, and the concentration depends on its physical, chemical, and biological activities along the river (Bora and Goswami 2017). The maximum concentration of DO was observed in winter, 7.05 (SS3) - 8.59 (SS2), which may be attributed to the low temperature in winter resulting in increased concentration of DO. Meanwhile, the minimum DO concentration in summer (5.04 -5.63mg/l) could be attributed to high microbial activities due to organic waste in the river water (Venkatesharaju 2010).

Biochemical oxygen demand: The presence of a high level of BOD in the water indicates the presence of organic waste and active microbial respiration in the river water (Semy and Singh 2019). The BOD in Dhansiri River ranged from 3.06-5.3 mg/l, with the highest value in winter (SS2) and the lowest concentration during summer (SS3). The rise of BOD could be attributed to high microbial activities triggered by organic pollution from the discharge of domestic waste and runoff from farmland and residential and commercial areas.

Potassium: In winter, the lowest K^+ value was 2.97 mg/l at SS1, while in summer, the highest value was 6.61 mg/l at SS3. Agricultural practices along the river stretch contribute to a rise in nutrient levels downstream. Semy and Singh (2019) have reported that the increase in K^+ levels in summer corresponds to nutrient runoff from cultivated lands that reach river bodies.

Sulphate: Sulphate is naturally found in river water in minute concentration or it can also occur from anthropogenic activities like mining (Titilawo et al 2019). The average SO_4^{2-} value in river water throughout the sampling stations varied from 7.94 mg/l (winter) to 15.58 mg/l (summer).

Nitrate: The seasonal NO_3^- concentration fluctuated from 0.05- 0.52mg/l, which was under the permissible limit of WHO/BIS. As per observation in the sampling stations, NO_3^- value increased from SS1 to SS3 throughout the seasons, presumably due to the influx of fertilizers from the agricultural land, which resonates with Meher et al (2015).

Inorganic phosphorus: The PO_4^{3-} concentration was maximum in autumn at SS3 (0.27 mg/l) and minimum in winter at SS1 (0.14 mg/l). The use of fertilizers and pesticides was observed at all sampling sites. Similar to the current findings, Semy and Singh (2021) stated that the extensive use of fertilizers and pesticides in the agricultural fields along the river banks increases PO_4^{3-} concentration during the pre-monsoon period.

Correlation analysis among water physicochemical parameters: pH is negatively correlated with WT, TDS, turbidity, K^+, SO_4^{2-} and NO_3^-, while positively significant with TH, TA, Ca^{2+}, Mg^{2+} and BOD indicating that an increase or decrease in the pH value will also exhibit change in increasing or decreasing of these water parameters (Table 4). The EC was positively significant with turbidity, K^+, SO_4^{2-}, and NO_3^- meanwhile, negatively significant ($p<0.01$) with TH, TA, Ca^{2+}, Mg^{2+}, DO, and BOD. A significant positive correlation is observed between Ca^{2+} and TA, which was also reported by Hussain et al (2021) due to the presence of carbonates, bicarbonates, and hydroxide in river water. Likewise, turbidity level showed a negative correlation with TH, TA, Ca^{2+} and Mg^{2+}, DO and BOD but positively significant with Cl⁻, K^+, SO_4^{2-} and NO_3^-. TH is positively significant at $p<0.01$ with TA, Ca^{2+}, Mg^{2+}, and BOD. A similar positive correlation was also observed between TH, TA and BOD (Rahman et al 2021) and TH and Mg^{2+} (Bhandari and Nayal 2008). DO shows a negative correlation with WT at $p<0.05$ indicates that oxygen decreases with increasing temperature. PO_4^{3-} did not show any significant relationship with other parameters. Some significant negative correlations were noted between pH, TA, Ca^{2+} Mg^{2+}, DO and BOD, which was consonant with the observation of Titilawo et al (2019). The correlation analysis reveals inter-relationships existing among the physical and

Table 4. Pearson's correlation coefficient matrix for the physicochemical water quality parameters

	pH	WT	TDS	EC	Turb	Cl⁻	TH	TA	Ca²⁺	Mg²⁺	DO	BOD	K⁺	SO₄²⁻	NO₃⁻	PO₄³⁻
pH	1															
WT	-0.902**	1														
TDS	-0.953**	0.895**	1													
EC	-0.908**	0.894**	0.943**	1												
Turb	-0.915**	0.909**	0.947**	0.977**	1											
Cl⁻	-0.593*	0.717**	0.567	0.661*	0.723**	1										
TH	0.933**	-0.981**	-0.919**	-0.938**	-0.941**	-0.752**	1									
TA	0.950**	-0.959**	-0.961**	-0.927**	-0.933**	-0.651*	0.976**	1								
Ca	0.790**	-0.894**	-0.740**	-0.781**	-0.802**	-0.861**	0.920**	0.845**	1							
Mg	0.846**	-0.866**	-0.802**	-0.814**	-0.839**	-0.553	0.890**	0.891**	0.815**	1						
DO	0.516	-0.628*	-0.532	-0.747**	-0.710**	-0.743**	0.690*	0.556	0.726**	0.548	1					
BOD	0.773**	-0.847**	-0.702*	-0.785**	-0.820**	-0.818**	0.862**	0.798**	0.856**	0.771**	-0.728**	1				
K⁺	-0.760**	0.831**	0.753**	0.871**	0.889**	0.870**	-0.864**	-0.772**	-0.870**	-0.702*	-0.853**	-0.854**	1			
SO₄²⁻	-0.859**	0.878**	0.893**	0.966**	0.974**	0.777**	-0.932**	-0.903**	-0.840**	-0.825**	-0.804**	-0.856**	0.913**	1		
NO₃⁻	-0.867**	0.867**	0.916**	0.966**	0.990**	0.721**	-0.906**	-0.902**	-0.752**	-0.808**	-0.713**	-0.804**	0.871**	0.975**	1	
PO₄³⁻	-0.392	0.505	0.503	0.495	0.481	0.297	-0.486	-0.536	-0.452	-0.497	-0.334	-0.411	0.433	0.465	0.461	1

**Correlation is significant at the 0.01 level (2-tailed)
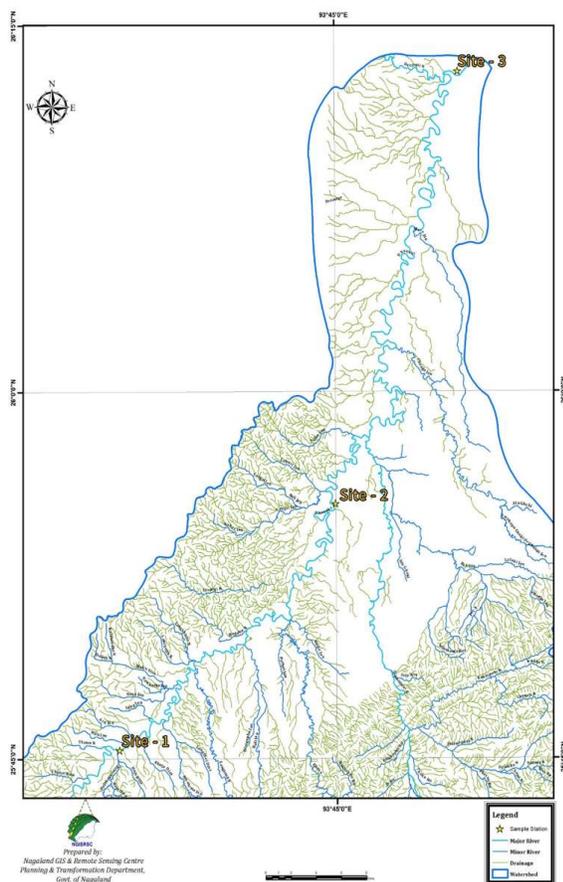*Correlation is significant at the 0.05 level (2-tailed)

Fig. 1. Drainage area map of the three-sampling location of Dhansiri river

chemical parameters of the Dhansiri river which has its impact on the function of the river system.

CONCLUSION

The physicochemical parameters of the three stations fluctuated seasonally, and the parameters WT, TDS, EC, turbidity, and Cl⁻ were high during summer while the variables TH, TA, Ca²⁺, and Mg²⁺ escalated during winter months. The anthropogenic activities, runoff waste debris, and other organic waste from the landfill areas have significantly impacted the water quality. The TA and turbidity of all three sampling locations were above the WHO/BIS permissible limit, indicating that the river water is unsuitable for use without proper treatment.

REFERENCES

APHA 1998. *Standard Methods for the Examination of Water and Wastewater*. 20th Edition, American Public Health Association, Washington DC.

APHA 2012. *Standard Methods for Examination of Water and Wastewater*. 22 Edition, American Public Health Association, Washington DC, USA.

Bhandari NS and Nayal K 2008. Correlation study of physicochemical parameters and quality assessment of Kosi River water Uttarakhand. *E-Journal of Chemistry* **5**(2): 342-346.

Bora M and Goswami DC 2017. Water quality assessment in terms of water quality index (WQI): Case study of the Kolong River, Assam, India. *Applied Water Science* **7**(6): 3125-3135.

Das M and Semy K 2023. Monitoring the dynamics of acid mine drainage affected stream surface water hydrochemistry at Jaintia Hills, Meghalaya, India. *Environmental Science and Pollution Research* **30**(30): 75489-75499.

Effendi H, Romanto and Wardiatno Y 2015. Water quality status of Ciambulawung River, Banten Province, based on pollution index and NSF-WQI *Procedia Environmental Sciences* **24**: 228-237.

Hussain M, Jamir L and Singh MR 2021. Assessment of physicochemical parameters and trace heavy metal elements from different sources of water in and around institutional campus of Lumami, Nagaland University, India. *Applied Water Science* **11**(4). DOI: 10.1007/s13201-021-01405-5.

Kumar RN, Solanki R and Kumar N 2011. An assessment of seasonal variation and water quality index of Sabarmati River and Kharicut canal at Ahmedabad, Gujarat. *Electronic Journal of Environmental, Agricultural and Food Chemistry* **10**(5): 2248-2261.

Kumar SK, Chandrasekar N, Seralathan P, Godson PS and Magesh NS 2012. Hydrogeochemical study of shallow carbonate aquifers, Rameswaram Island, India. *Environmental Monitoring and Assessment* **184**(7): 4127-4138.

Meher PK, Sharma P, Gautam PY, Kumar A, Mishra KP, Nagarani N, Arumugam K, Kumaraguru VJ, Devi C and Archana D 2015. Evaluation of water quality of Ganges River using water quality index tool. *Environment Asia* **8**(1): 124-132.

Nandal A, Kaushik N, Yadav SS, Rao AS, Singh N and Gulia SS 2020. Water quality assessment of pond water of Kalanaur Block, Rohtak, Haryana. *Indian Journal of Ecology* **47**(1): 1-6

Rahman A, Jahanara I and Jolly YN 2021. Assessment of physicochemical properties of water and their seasonal variation in an urban river in Bangladesh. *Water Science and Engineering* **14**(2): 139-148.

Sarmah R, Dutta R, Bhagabati SK, Nath D, Mudoi LP, Pokhrel H and Ahmed AM 2020 Seasonal variation of water quality parameters of river Dikhow in Nagaland and Assam. *International Journal of Chemical Studies* **8**(5): 1429-1434.

Semy K and Singh MR 2019. Assessment on the water quality of Tsurang River, Nagaland affected by coal mining drainage.

Indian Journal of Ecology **46**(4): 845-849.

Semy K and Singh MR 2021. Quality assessment of Tsurang River water affected by coal mining along the Tsurangkong Range, Nagaland, India. *Applied Water Science* **11**(7).

Seth R, Mohan M, Singh P, Singh R, Dobhal R, Singh KP and Gupta S 2016. Water quality evaluation of Himalayan Rivers of Kumaun region, Uttarakhand, India. *Applied Water Science* **6**(2): 137-147.

Singh KP, Malik A, Mohan D and Sinha S 2004. Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India): A case study. *Water Research* **38**(18): 3980-3992.

Singh PK and Shrivastava P 2015. Analysis of water quality of river Narmada. *International Journal of Current Research* **7**(12): 24073-24076.

Titilawo Y, Akintokun A, Shittu O, Adeniyi M, Olaitan J and Okoh A 2019. Physicochemical properties and total coliform distribution of selected rivers in Osun state, Southwestern Nigeria. *Polish Journal of Environmental Studies* **28**(6): 4417–4428.

Trivedy RK and Goel PK 1986. Chemical and Biological method for water pollution studies. *Environmental Publication* **6**: 10-12.

Trivedi P, Bajpai A and Thareja S 2009. Evaluation of Water Quality: Physicochemical Characteristics of Ganga River at Kanpur by using Correlation Study. *Nature and Science* **1**(6). http://www.sciencepub.net

Venkatesharaju K, Ravikumar P, Somashekar RK and Prakash KL 2010. Physicochemical and bacteriological investigation on the river Cauvery of Kollegal stretch in Karnataka. *Kathmandu University Journal of Sciences, Engineering and Technology* **6**(1): 50-59.

Venkatramanan S, Chung SY, Lee SY and Park N 2014. Assessment of river water quality via environmentric multivariate statistical tools and water quality index: A case study of Nakdong River Basin, Korea. *Carpathian Journal of Earth and Environmental Sciences* **9**(2): 125-132.