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Assessment of physico-chemical and heavy metals in water samples from Bashkandi Lake in South Assam: Multivariate analysis

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ABSTRACT

Physico-chemical characteristics and heavy metal concentration of a wetland site in Barak valley, South Assam (Baskandi anua) were analyzed for a year in order to comprehend the water quality. Water quality criteria examined included various physico-chemical and heavy metal parameters such as dissolved oxygen, pH, hardness, chloride, free chlorine, Nitrate, total suspended solids, Sulphate, total dissolved solids, Ca, Mg, Fe, Pb, Cd and Ni using standard techniques. The findings were compared with World Health Organization water quality criteria. Multivariate analysis was also employed to find the possible sources. The study revealed that some physico-chemical parameters and heavy metal concentration showed substantial change, but the majority of the values fell within the normal range and suggested that the lake water was in good condition.

Key words: *Heavy metals, Physico-chemical parameters, Wetland water, Anthropogenic activities, Multivariate analysis.*

Introduction

Wetlands help in replenishing surface water, regulating climate, purifying the environment, and supporting biodiversity apart from providing essential ecosystem services such as reducing nutrient and pollution loads from storm water before it enters the receiving waters (Townsend *et al.,* 2019). Wetland water quality and their ecological function are directly impacted by numerous anthropogenic influences like effluent discharge, industrial and run-off from agriculture, as well as urban and airborne deposition, that can contaminate wetlands and lead to decline in water feature and ecosystem operation (Piacente *et al.,* 2020). Such impact on water quality can be easily reflected in the variation of physico-chemical parameters, also called Water quality indices (WQI) (Fatima *et al.,* 2022). WQI is extensively employed for assessing the quality of water for monitoring and assessment purpose (Uddin *et al.,* 2021; Khangembam, 2019). Common WQI include dissolved oxygen (DO), pH, hardness, chloride, free Chlorine, nitrate, total suspended solids (TSS), sulphate, total dissolved solids (TDS), Ca, Mg, Fe, Pb, Cd and Ni; and comparison is made in terms of standard water quality guidelines (WHO, 2011). Often, the Physico-chemical and heavy metal analysis of wetland water is good indicators of a wetland health (Bano *et al.,* 2022). Nonetheless, it is still necessary to investigate probable naturally occurring sources and implications of human-induced actions on water quality Rather *et al.* (2022).

Baskandi anua is a floodplain oxbow lake formed by the River Barak in South Assam, India. Anua is the local terminology of oxbow lake. This lake serves as a primary water supply and livelihood for the inhabitants as the lake harbors variety of fish. Prior study showed that the physico-chemical parameters and heavy metal analysis of this lake are conducive to fish growth (Gupta and Devi, 2014). However, recent increase in pollution and anthropogenic activities has impacted its water quality.

Therefore, the current study, aims at estimating the WQI in terms of dissolved oxygen, pH, hardness, chloride, free chlorine, total suspended solid, total dissolved solids, nitrate, sulphate, Ca, Mg, Fe, Pb, Cd and Ni from this oxbow lake and to find the potential origins through multivariate statistical analysis.

Materials and Methods

Study area

The study site is situated in Bashkandi area of Cachar District, South Assam with latitude and longitude 24°48'32.4"N 92°55'02.7"E (Fig. 1). The lake is often referred to as Bashkandi Anua owing to its distinctive horseshoe-shaped created by the Barak River. The Bashkandi Anua Lake has significant importance due to its rich biodiversity and crucial supply of drinking water.

Sample collection and analysis

Samples were collected from the lake from January to December for one year. Water samples from various sampling sites were collected in BOD bottles (for estimating dissolved oxygen) and for rest of the WQI in sample bottles was washed in 50% nitric acid after being rinsed with the sample water three to four times, and brought right away to the lab for analysis like Dissolved Oxygen (DO), pH, hardness, Chloride, Free Chlorine, TSS, TDS, nitrate, sulphate, Ca, Mg, Fe, Pb, Cd and Ni. The physicochemical properties and heavy metals in water were examined using standard techniques (APHA, 2005) and ICP-OES (Inductively Coupled Plasma-Optical Emission Spectroscopy).

Statistical analysis

All of the data was performed statistically by IBM SPSS version 25. Pearson correlation analysis is used for examining it's inter relationship between metals. Principal component analysis is carried out in finding its probable origin of pollution. KMO and varimax rotation was incorporated to validate the data. Cluster analysis was also carried out to find the dissimilar and similar sources by using wards method. The map was generated using QGIS software version 3.22 (Fig. 1).

Results and Discussion

Physico-chemical parameters and Concentration of heavy metal in water

The result of descriptive statistical analysis of heavy metal concentration in water sample is presented at Table 1.

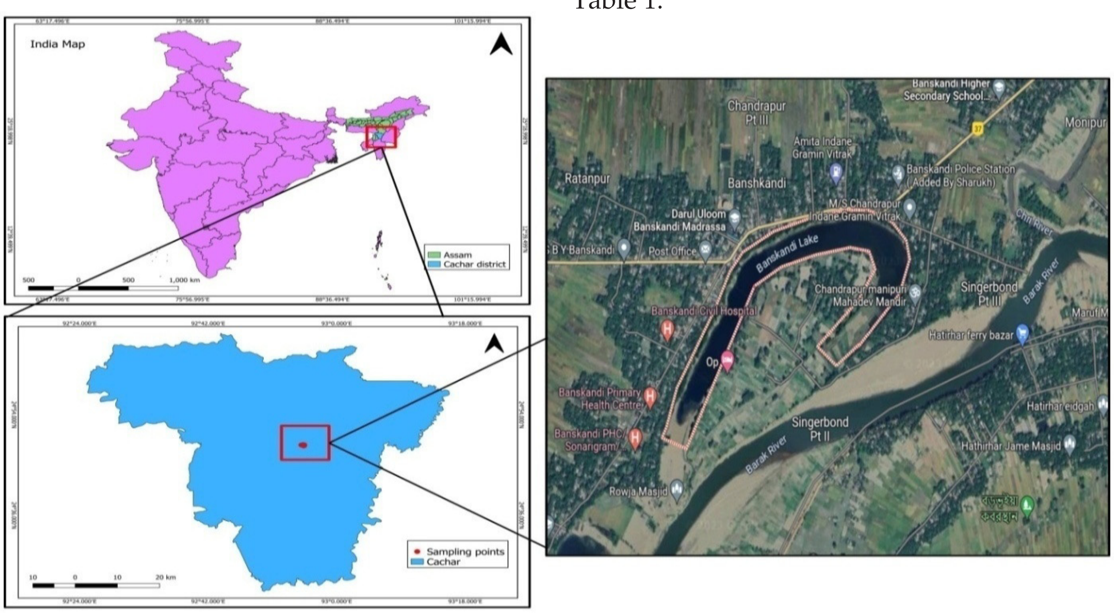

Fig. 1. Map showing the sample site of Bashkandi Anua (24°48'32.4"N 92°55'02.7"E).

The concentration of dissolved oxygen, pH, hardness, chloride, free chlorine, total suspended solid, total dissolved solids, nitrate, sulphate, Ca, Mg, Fe, Pb, Cd and Ni in water was found to be 6.75±0.47, 5.32±0.68, 39.14±3.16, 0.03±0.02, 2.70±0.35, 20.30±1.46, 42.09±3.24, 2.88±0.20, 0.01±0.01, 0.39±0.45, 0.009±0.002, 0.01±0.005, 0.004±0.002, 0.004±0.002, and 0.003±0.001 mg/l respectively. The results in the research area showed that DO, pH, hardness, chloride, free chlorine, total dissolved solids, nitrate, sulphate, Ca, Mg, Fe, Pb, Cd and Ni are within the recommended limit as per WHO (2011). However, TSS was found to be exceeding the recommended limits. Thus, the current data revealed that almost all the matrices shows no such exceeding value, indicating that anthropogenic activities have not negatively impacted the wetland and was also similarly reported in literatures (Akhtar *et al*., 2021; Ali *et al*., 2018; Ansari *et al.,* 2017; Asati *et al*., 2016; Bandar *et al*., 2021; Gopi *et al*., 2021; Hussain *et al*., 2021; Laskar *et al*., 2022; Nasir 2010; Negi *et al.,* 2022; Proshad *et al*., 2020; Whitehead *et al.,* 2018). Whereas the elevated limit of TSS was due to the industrial effluent and harmful application of chemicals in the Lake (Rahman *et al.,* 2021). However, we still cannot omit that the minimal presence of these hazardous elements in the long term can still be a threat to human health and deterioration of Lake Ecosystem. Therefore, these findings suggest that constant monitoring and precautionary steps should be implemented to avoid future contamination.

Pearson correlation

To know the inter relationship among the parameters, Pearson correlation analysis was carried out (Table 2). The result shows both positive and negative correlation. DO showed a significant negative correlation with Ca and Mg (r = -0.711, P≤0.05 and r = -0.820, P≤0.01). The pH showed a significant positive correlation with hardness, TSS and TDS (r = 0.877, 0.882, and 0.911, P≤0.05). Hardness had significant positive correlation with TSS, TDS, and sulphate (r = 0.983, 0.940, 0.818, P≤0.01). Nitrate had a negative correlation with pH, hardness, TSS and TDS (r = -0.675, P≤0.05 and r = -0.850, -0.810, -0.846, P≤0.01). Sulphate had a significant positive correlation with TSS (r = 0.782, P≤0.05). Ca was showing a significant negative correlation with free chlorine (r = -0.806, P≤0.01). Mg has a significant positive correlation with Ca (r = 0.711, P≤0.05). Pb is significantly negatively correlated with chloride, Ca, and Fe (r = -0.678, -0.722, -0.718, P≤0.05) while Pb and sulphate is showing significant positive correlation (r = 0.697, P≤0.05). Moreover Cd and Ni did not have a significant correlation with other. Thus from this study, those with significant positive correlation indicates that it has come from a common sources whereas those with significant negative correlation indicates that is coming from natural or other sources.

Principal component analysis

In order to identify the probable sources properly and understand better relationship within the met-

Table 1. Descriptive statistical analysis of physico-chemical and concentration of heavy metal in water (mg/l)

Parameters	Mean	Range	Median	SD	Skewness	Kurtosis	K-S	Permissible limit (mg/l) (WHO, 2011)
DO	6.75	6.00-7.40	6.90	0.473	-0.723	-0.112	0.190	6.5-8
pH	5.32	4.40-6.08	5.20	0.686	-0.106	-1.976	0.130	6.5-8.5
Hardness	39.14	36.05-43.50	38.22	3.167	0.548	-1.692	0.096	500
Chloride	0.03	0.01-0.08	0.03	0.021	1.019	1.443	.200*	250
Free Chlorine	2.70	2.09-3.04	2.70	0.350	-0.979	-0.221	0.060	NL
TSS	20.30	18.50-22.09	20.20	1.465	0.164	-1.711	.200*	10
TDS	42.09	37.08-47.02	42.35	3.248	-0.077	-0.904	.200*	1000
Nitrate	2.88	2.45-3.06	2.98	0.205	-1.509	1.715	0.140	12
Sulphate	0.01	0.004-0.04	0.007	0.012	1.733	2.820	0.009	250
Ca	0.39	0.08-1.00	0.09	0.457	0.857	-1.714	0.000	150
Mg	0.009	0.006-0.01	0.01	0.002	0.157	-0.401	.200*	100
Fe	0.01	0.01-0.02	0.02	0.005	-0.285	-1.877	0.013	0.3
Pb	0.004	0-0.009	0.003	0.002	0.536	-0.121	.200*	0.3
Cd	0.004	0.001-0.008	0.005	0.002	0.095	-1.407	.200*	0.2
Ni	0.003	0.001-0.007	0.003	0.001	1.094	0.963	.200*	0.7

Table 2. Pearson correlation analysis of various matrixes in water

Parameters	DO	pH	Hardness	Chloride	Free Chlorine	TSS	TDS	Nitrite	Sulphite	Ca	Mg	Fe	Pb	Cd	Ni
DO	1														
pH	-0.169	1													
Hardness	-0.161	0.877**	1												
Chloride	-0.318	-0.356	-0.370	1											
Free Chlorine	0.579	-0.314	-0.152	-0.545	1										
TSS	-0.262	0.882**	0.983**	-0.318	-0.296	1									
TDS	-0.367	0.911**	0.940**	-0.189	-0.374	0.955**	1								
Nitrate	0.128	-0.675*	-0.850**	0.074	0.193	-0.810**	-0.846**	1							
Sulphate	-0.002	0.645	0.818**	-0.577	0.226	0.782*	0.652	-0.475	1						
Ca	-0.711*	0.003	-0.235	0.421	-0.806**	-0.082	0.027	0.230	-0.443	1					
Mg	-0.820**	-0.058	-0.164	0.410	-0.442	-0.098	0.006	0.194	-0.191	0.711*	1				
Fe	-0.457	-0.067	-0.122	0.558	-0.615	-0.051	0.028	-0.071	-0.332	0.665	0.666	1			
Pb	0.362	0.550	0.646	-0.678*	0.474	0.542	0.435	-0.436	0.697*	-0.722*	-0.524	-0.718*	1		
Cd	0.033	-0.134	-0.324	0.342	0.117	-0.388	-0.121	0.006	-0.495	0.003	0.046	0.003	-0.220	1	
Ni	-0.557	0.332	0.219	-0.305	-0.387	0.300	0.348	-0.200	-0.058	0.582	0.346	0.241	-0.073	-0.128	1

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

als principal component analysis was carried out. The results in Table 3 show that only four components were observed with eigenvalue greater than 1 and accounts 87.73% of the total variance (Fig. 2). In PC1 it is strongly loaded with pH, hardness, TSS, TDS, sulphate and Pb which accounts for 36.05% variance and shows that they are from a common source. The pH, hardness, TSS and TDS is mainly associated to industrial effluent, municipal and domestic waste (Phungela *et al.,* 2022; Ramadas *et al.*, 2005; Sangawe *et al.,* 2023), Pb is mostly related to vehicular emission and transport (Hosen 2021; Mishra *et al.,* 2021). PC2 explains for 31.32% and is strongly loaded with chloride, Ca, Mg, and Fe which shows that they have come from anthropogenic sources.

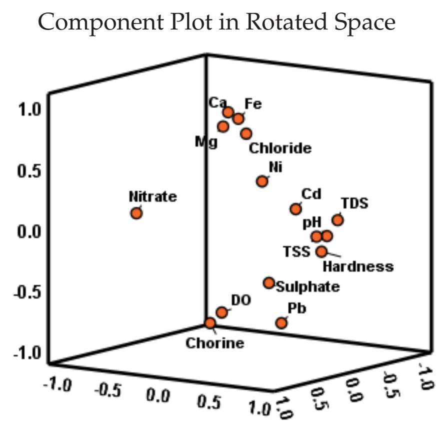

Fig. 2. Result of PCA analysis in water samples in the study area

The presence of chloride, Ca, Mg and Fe is related to weathering of rock, sewage waste discharges and agricultural activities (Baruah and Baruah, 2022; Bhat *et al.,* 2022; Rashid *et al.,* 2022) except for DO which is showing negative value indicating that it is coming from different sources. PC3 accounts for 10.22% and is loaded with free chlorine, nitrate and Cd but the loadings were showing low or negative value which indicates that they have come from different sources most likely to be from human activities like disposal of domestic and municipal wastes (Ajibade *et al.,* 2020; Uddin *et al.*, 2021). PC4 is strongly loaded with Ni which accounts for 10.13% indicating that it has come from untreated wastewater from small workshop and industries (Tabak *et al.*, 2020; Townsend *et al.,* 2019). Interestingly, the finding shows that all the parameters were below the WHO permissible. Thus concluding that the water

Table 3. Results of PCA in tested water sample

Variables	Factor loading in water samples			
	PC1	PC2	PC3	PC4
DO	-0.203	-0.761	-0.035	-0.372
pH	0.896	-0.009	0.054	0.236
Hardness	0.964	-0.105	0.228	0.065
Chloride	-0.187	0.663	-0.355	-0.581
Free Chlorine	-0.279	-0.848	0.022	0.014
TSS	0.951	0.025	0.279	0.104
TDS	0.976	0.124	0.018	0.141
Nitrate	-0.909	0.011	0.160	0.099
Sulphate	0.673	-0.345	0.552	0.026
Ca	-0.146	0.889	-0.042	0.350
Mg	-0.129	0.787	0.053	0.240
Fe	-0.032	0.850	-0.023	-0.142
Pb	0.538	-0.742	0.183	0.128
Cd	-0.115	-0.035	-0.951	-0.031
Ni	0.209	0.361	-0.015	0.852
Eigenvalue	5.408	4.699	1.534	1.521
% of Variance	36.051	31.324	10.226	10.138
Cumulative %	36.051	67.375	77.601	87.739

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization[a]; a. Rotation converged in 6 iterations

conditions in the investigated region is not polluted. However, precautionary steps and maintenance must be taken up for maintaining its biodiversity and human use as it still pose a risk of contamination in longer duration.

Cluster analysis

CA is implemented by applying Ward's method and Euclidean distance as a metric for measuring similarity (Fig. 3). In this dendrogram, four clusters can be observed. In Cluster 1 it is composed of Pb, Cd, Ni, sulphate, Mg, Fe, chloride, Ca, Free chlorine, nitrate, DO, and pH. Cluster 2 comprises of hardness. Cluster 3 includes TDS while cluster 4 includes TSS. Thus from this studies it shows that PCA and CA were in agreement with each other.

Conclusion

To be able to assess the level of water contamination at Bashkandi Lake, this study looked at changes in water quality. The outcome from the aforementioned research suggested that physico-chemical and heavy metal concentrations are falling within the WHO (2011) acceptable limit except for total suspended solid which was beyond the recommended

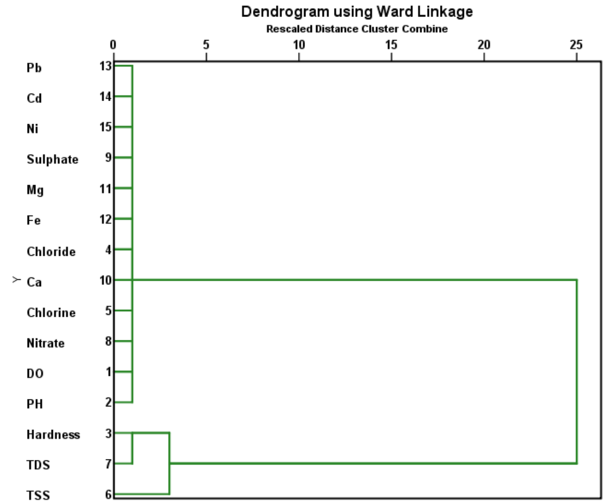

Fig. 3. Result of Cluster analysis in water samples in the study area

level. Pearson correlation, PCA, and CA also showed negative significant relationship. Thus, according to the results of this research, the aquatic ecosystem of the Bashkandi wetland showed that no such harmful chemicals were found to be introduced in the water and was in normal conditions; hence it is significant for maintaining a high biodiversity and human use.

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Conflict of interest

The authors wish to declare no conflict of interest.

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