IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 13, Issue 7 Ser. I (July. 2020), PP 33-50
www.iosrjournals.org

Evaluation of Water Quality for Aquaculture: Physico – Chemical Characteristics of Hau River (Mekong Delta) with reference to Correlation Study

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Abstract:
Background*: Present work deals with the assessment of Physico-chemical parameters of water samples of Hau River in An Giang and Can Tho Provinces in Vietnam with six sampling sites each. This is because there has been increasing land use around Hau River in the recent past whose activities significantly affect water quality parameters, therefore, making it crucial to assess the water quality in these areas.*
Materials and methods*: The water samples were collected and analyzed monthly from January to December 2019. The purpose of this study was to assess the water quality parameters along the Hau River to establish the possible setbacks associated with its deterioration and thus derive recommendations.A correlation matrix was used to determine Pearson's correlation coefficient (r) value to identify the water quality parameters that were both highly correlated and interrelated.Differences in each pair of parameters were analyzed using multivariate means in Minitab software Version 19.2020.1.0.*
Results:*The results parameters were compared with the desirable ranges for aquaculture as recommended by various authors. It was found that there was an appreciable significant positive correlation or Temperature vs Salinity at AG5 (r=0.611, p<0.05) and DO at CT8 (r=0.577, p<0.05); pH vs DO (r=0.636, p<0.05); DOvs Total Coliform at CT9 (r=0.762, p<0.01) and BOD at CT8 (r=0.589, p<0.05); Alkalinity vs BOD (r=0.654, p<0.05), NO_3^-(r=0.617, p<0.05), and DO (r=0.736, p<0.05), . A significant negative correlation was found between Salinity vs TSS (-0.745, p<0.01); TAN vs Total Coliform (r=-0.684); Nitrate vs Phosphate at CT6 (r=-0.701, p<0.05), and pH vs NO_3^- (r=-0.682, p<0.05), TAN (r=-0.698, p<0.05), PO_4^{3-} (r=-0.641, p<0.05), and Salinity (r=-0.605, p<0.05). Phosphate and Total Coliform hadnon-significant correlation with other parameters.*
Conclusion:*It can, therefore, be concluded that most of the water quality parameters in Hau River were within the desirable ranges for aquaculture except DO, which was slightly below while, on the other hand, BOD and Total Coliform were above the desirable ranges for aquaculture.*
Key Word*: Water quality; Pearson's correlation; Anthropogenic; Deterioration*

Date of Submission: 26-07-2020 Date of Acceptance: 10-08-2020

I. Introduction

Freshwater systems, which include water resources such as rivers, streams, and wetlands and the oceans are under ever-increasing anthropogenic and natural stress such as loss of habitat, aquatic pollution, overfishing, and climate change which presents new challenges for wildlife and humanity[1]. Their aesthetic value, together with amenity, is reduced by poor water quality, which is brought about by rapid population growth, industrialization, and intensive agricultural development, which act as sources of pressure that have been causing environmental degradation[2]. The Mekong River is not an exception despite supporting the livelihood of residents with the lower Mekong Delta providing homes to about 18 million people Vietnamese[3]. This is because the water quality is becoming ruined from upstream to downstream in many parts of the basin leading to adverse effects on the diversity and productivity of freshwater species and ecosystems (both terrestrial and aquatic)[4].

Natural factors such as changes in temperature, rainfall, and rock-weathering together with anthropogenic activities, limit the natural flow of the river and alter its hydrochemistry, thus influencing the quality and quantity of the river[5].The discharges from industrial, domestic, and agricultural activities can also change the water chemistry, thus leading to the degradation of the aquatic ecosystems[6]such as water quality deterioration in the rivers.This is a clear indication that surface water quality of any water resource is controlled by both anthropogenic factors such as agricultural, urban, and industrial activities and natural processes such as soil erosion, precipitation, and weathering processes[7,8,9].The seasonal variations in the natural factors like

surface run-off, the flow of groundwater, rain, abstraction, and interception significantly affect both the concentrations of pollutants in the river and its discharge[10].

Hau River (also known as the Bassac River) plays a significant part in the daily life of the local people as well as contribute to various production types[11]. Unfortunately, the provisioning, regulating, supporting, and cultural services of Hau River have been overused, and the water quality is deteriorating with increasing nutrient levels and decreasing oxygen levels as a result of eutrophication. Hau River is facing increasing pressure from the overwhelming human activities such as agriculture, aquaculture, an increased number of boats, and industries[12].

Le and Thuy[13]pointed out that currently, Hau River is facing many challenges such as water quality declination, narrowing of natural lowlands during the urbanization processes, changes in hydrological flow characteristics, expansion of agriculture and fisheries production activitiesand effects of climate change, such as the sea-level rise and further saltwater intrusion. This shows that the anthropogenic activities and natural processes have greatly affected the surface water quality of this river. This issue can only be solved through scientific and reasonable water quality assessment methods as a significant basis for ensuring proper water quality management and assessment to save the water resource. That is why this study aimed at assessing the water quality of the Hau River to be able to identify potential pollutant sources to prevent and control water pollution.

II. Materials and methods

Study site: The Hau River is one of the main branches of the Mekong River that is located at the most southern side of the Mekong. Hau River splits into two sub-branches, namely: Tran De and Dinh An, as it approaches the sea[14]and releases a total quantity of water amounting to approximately 215 billion m^3 per year into the sea[13].

This accounts for approximately 41% of the total Mekong water discharge, whereby 30% of the release flows through the Tran De channel, while 70% of it flows through Dinh An channel[14]. Thispositions Hau River as having the most magnificent water discharge compared to other rivers in Vietnam because it can reach the extent of draining around 90% of Mekong River's peak floodwater, not forgetting its total annual flow of nearly 215 billion cubic meters[13].

The Hau River has a length of 225-km and width of approximately 60— 300 m upon entering Vietnam, although the river widens gradually as it flows to the sea. It has an average depth of 10-20m,and the maximum depth is over 40m. Unfortunately, sedimentation has caused a decrease in the depth as the river nears the sea[13]. Hau River has a large flow velocity ranging from 1.0 to 2.98 m s^{-1}[15,] withthat of the river mouth being as high as1.5 m/s despite the low water exchange between the river and the delta. The persistence of high flow velocity for long periods has led to erosion of the river mouth, thus leading to the formation of individual deep gutters[16].

III. Sampling and Analysis

The water samples were collected for a period of 12 months from January to December 2019 from 12 sampling sites representing the water quality of Hau River. The water quality parameters assessed consisted of temperature, pH, DO, salinity, BOD, alkalinity, TAN, $N\text{-}NO_3^-$, TSS, NH_3, $P\text{-}PO_4$,and TotalColiform. The samples were collected using clean 100ml plastic bottles, and each bottle was tightly closed using a plastic bag then put in a cooler box with ice to ensure proper preservation of the samples while in the field and during transportation to the laboratory. All the samples were preserved and analyzed according to the American PublicHealthAssociation(APHA)standardmethods(APHA)[17].Temperature, pH, salinity, and DO were measured directly at the site. At the same time, the other parameters were analyzed by applying fundamental methods used at the water quality laboratory of Can Tho University.

Statistical Analysis

Statistical analysis was carried out using MINITAB (version 19.2) and IBM SPSS (version 20). All the water quality parameters for the 12 study sites were analyzed by calculating Pearson's Correlation (r) coefficient value. A correlation matrix was constructed by calculating the coefficients of different pairs of water quality parameters to calculate the correlation coefficients. The correlation significance was further tested by applying p-value. The variations were considered significant if $p<0.05$, $p<0.01$, and non- significant if $p>0.05$. The significance was discussed at the level of 0.01 and 0.05 (2-tailed analysis).

IV. Results and Discussion

The statistical results for surface water quality of Hau River with respect to the mean, median, Standard deviation, variance, covariance, kurtosis, skewness, minimum, maximum, sum, and desirable ranges for aquaculture are summarized in Table 1.Monthly variation of the water quality parameters are represented in

graphs. The same water quality parameters are depicted in table 2,3,4,5,6,7,8,9,10,11,12 and 13with correlation matrix.

Table 1: Monthly variation of water quality for the sampled sites in 2019

	Temp (°C)	pH	Alkalinity (mg/L)	DO (mg/L)	Salinity (mg/L)	TSS (mg/L)	TAN (mg/L)	BOD_5 (mg/L)	NO_3^- (mg/L)	PO_4^{3-} (Mg/L)	TC (MPN×10^3/100ml)
Mean	30.47	7.2687	63.972	4.794	134.4	38.73	0.1951	3.4387	0.1981	0.184	23.69
Median	30.49	7.28	66.55	4.8	136	34	0.178	3.22	0.2175	0.1392	13
St. Dev.	1.232	0.2614	15.022	0.8423	31.38	21.61	0.1592	1.0525	0.08218	0.1614	30.29
Sample variance	1.518	0.0684	225.663	0.7094	984.84	466.99	0.0254	1.1077	0.00675	0.026	917.3
CV%	4.04	3.6	23.48	17.57	23.35	55.8	81.62	30.61	37.39	87.72	127.87
Kurtosis	-0.91	-0.56	-1.08	-0.53	0.79	0.86	2.16	-0.14	1.01	0.84	4.62
Skewness	-0.09	0.16	-0.31	0.01	0.27	1.18	1.32	0.55	0.25	1.26	2.17
Min	27.93	6.67	33	2.97	49	4.6	0.004	1.192	0.0025	0.0045	0.2
Max	33.32	7.98	93	6.79	226	104	0.865	6.18	0.489	0.6595	150
Sum	6947.18	1657.3	14585.58	1093.026	30643.4	8829.5	44.4819	784.013	50.1176	41.944	5400.33
Desirable range	20-32	6.5-9	25-100	5--15	0-5000	25-150	<0.01	1--2	0.1-4.5	0.05-0.5	0.1-5

Temperature

The maximum temperature was 32.9^0 C in AG6 during April, and the minimum was 27.9^0 C in AG3 (December) with an annual mean of 30.47^0 C±1.232 (Table 1, Figure 2), which is within the desirable ranges for aquaculture as prescribed byKasnir[18].The variation of temperature is as a result of changes in the weather conditions. The high temperature in April can be attributed to climate change.

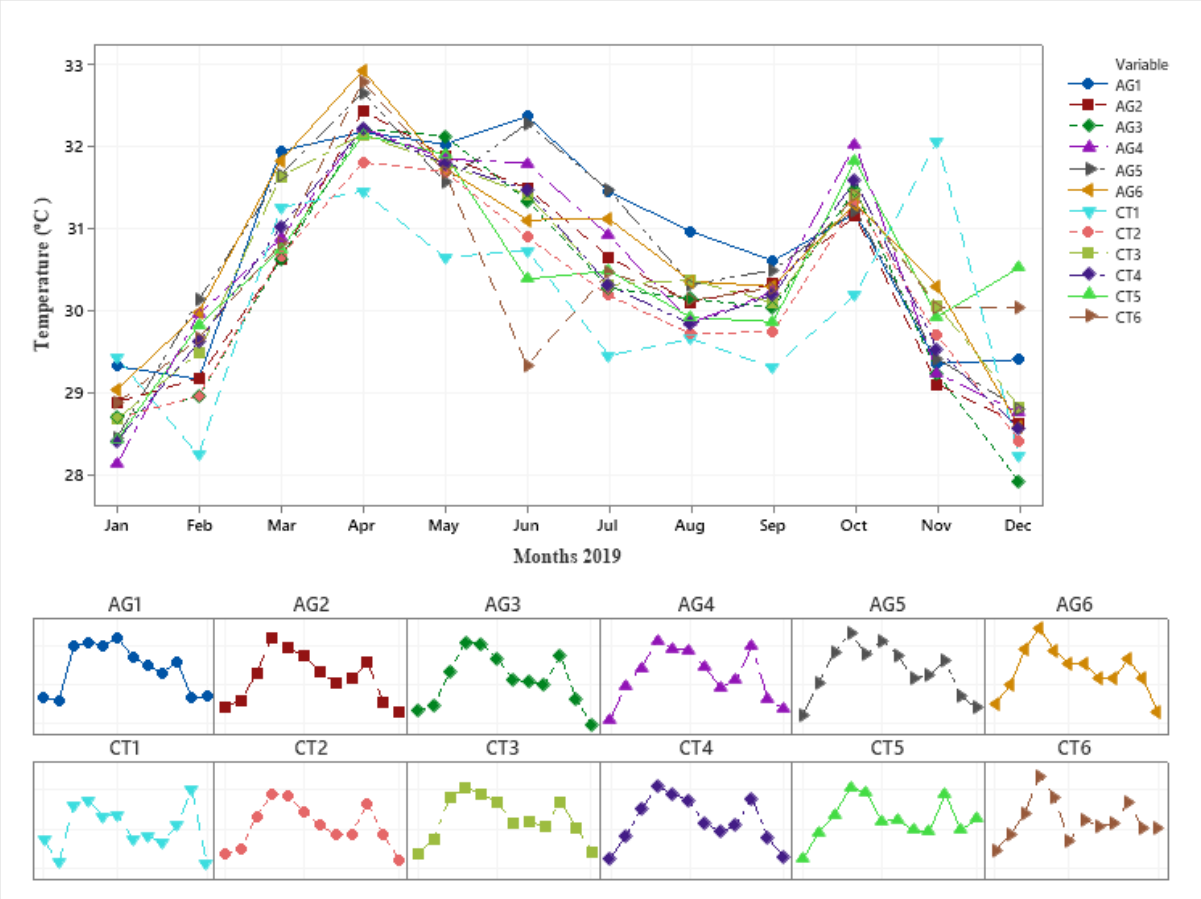

Figure 2 Graph showing the monthly variation of temperature for the sampled sites

In this study, the temperature showed a significant and positive correlation with Salinity at AG3 ($r=0.611$, $p<0.05$) and DO at CT5 ($r=0.577$, $p<0.05$). On the other hand, temperature showed a significant and

negative correlation with BOD at AG4 (r=-0.619, p<0.05) and NO_3^- at CT5 (r=-0.604, p<0.05). This shows that an increase or decrease in the values of temperature will lead to a decrease or increase of BOD and NO_3^- values.

pH

During the study, the pH ranged from 6.67 to 7.85, indicating that the nature of water was slightly acidic and basic. The maximum pH was in Dec (CT5), while the minimum was in Dec (AG5) with an annual mean of 7.27±0.261 (Table 2, Figure 3.2). The PH values were within the desirable ranges for aquaculture, according to(Bhatnagar and Devi[19].

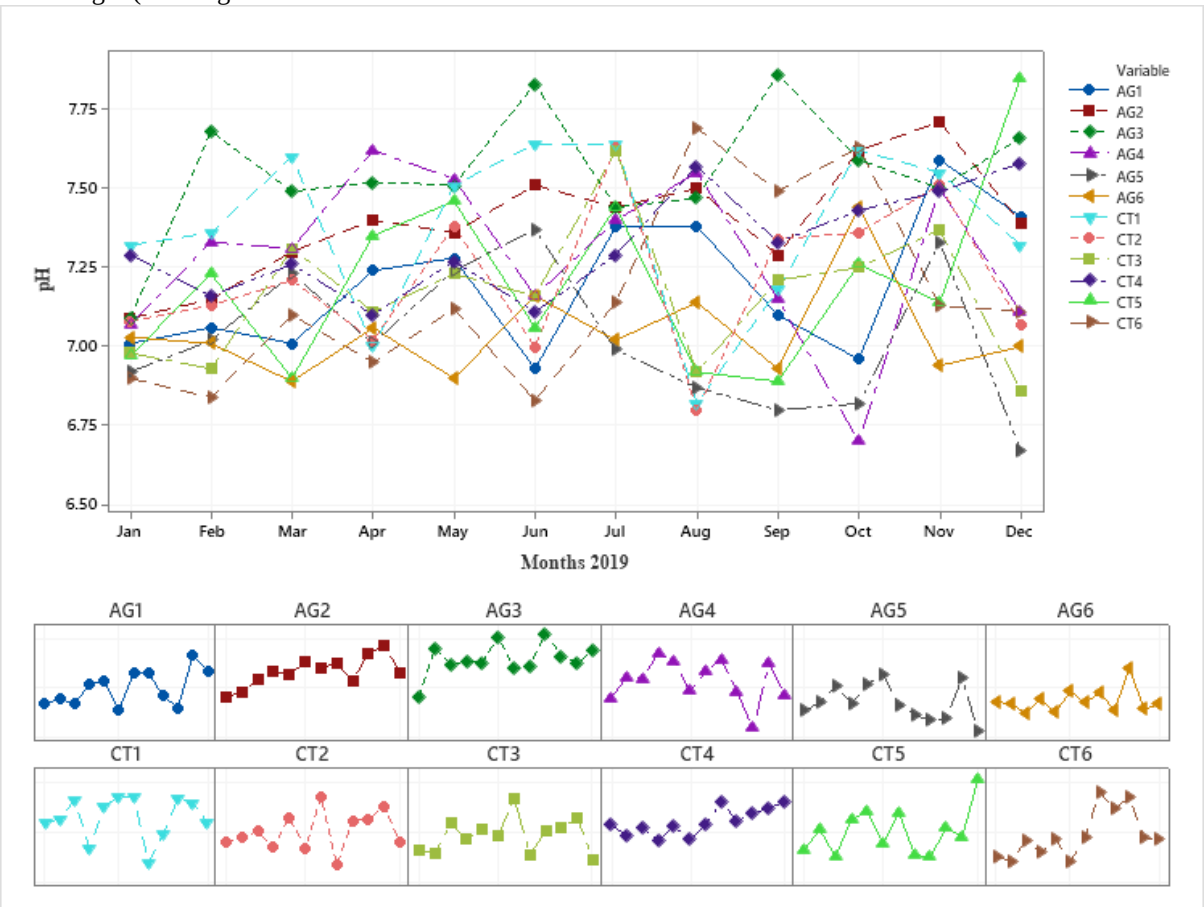

Figure 3 Graph showing monthly variation of pH for the sampled sites

In this study, the pH showed a significant and positive correlation with DO (r=0.636, p<0.05) and on the other hand there was a significant negative correlation with NO_3^- (r=-0.682, p<0.05), TAN (r=-0.698, p<0.05), PO_4^{3-} (r=-0.641, p<0.05), and Salinity (r=-0.605, p<0.05). The pH versus TSS showed a maximum correlation at CT4 (r=0.614, p<0.05) and minimum at AG1 (r=0.581, p<0.05), pH versus Alkalinity showed maximum correlation at CT4 (r=-0.637, p<0.05) and minimum at CT6 (r=0.630, p<0.05).

DO

The DO of the surface water ranged from 2.97 to 6.8 mg/L. At the sampling site, CT1 (Aug) recorded the lowest value while it was highest at AG4 (February) with an annual mean of 4.8±0.84mg/L (Table 2, Figure 3.3). This was below the desired aquaculture ranges, which should be between 5-15mg/L[20].

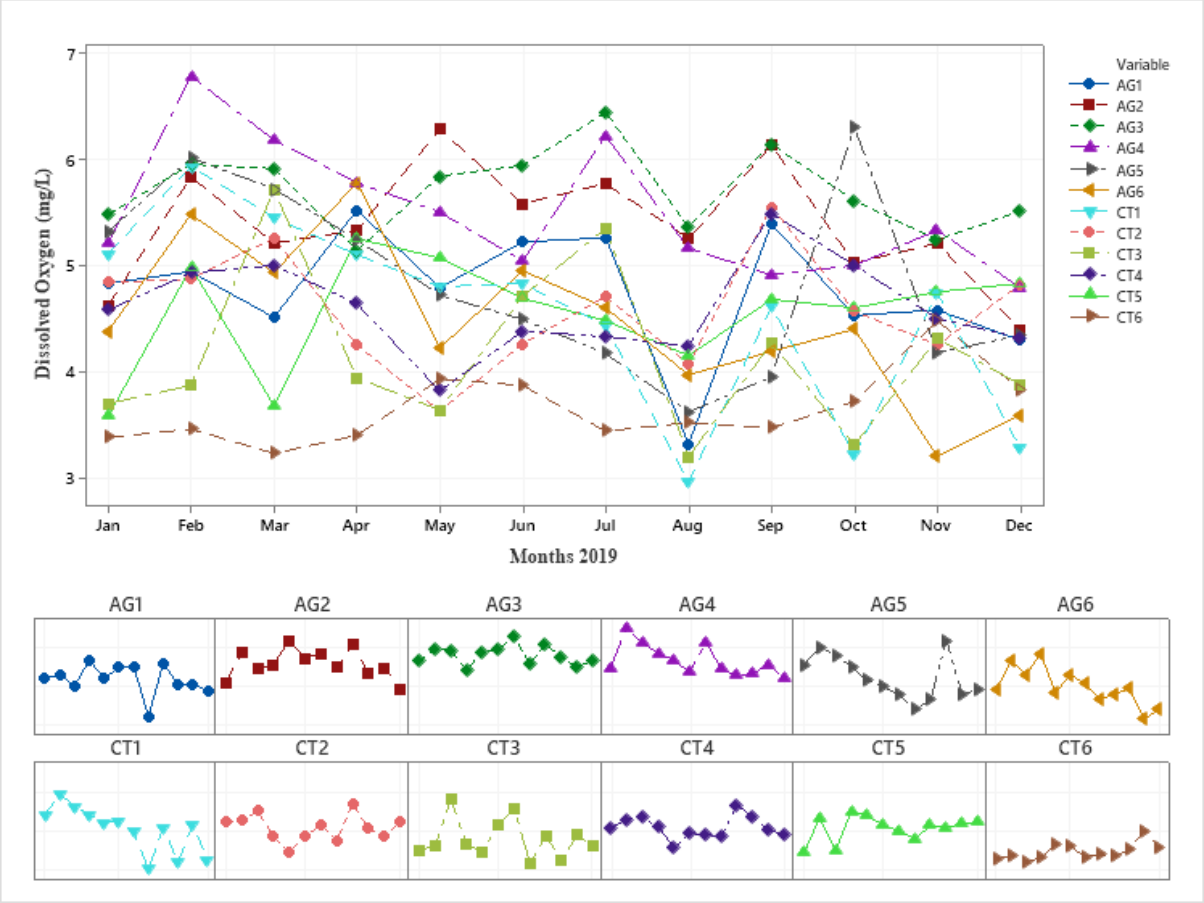

Figure 4 Graph showing the monthly variation of Dissolved Oxygen for the sampled sites

In this study, DO showed a strong significant, and positive correlation with Total Coliform at CT6 ($r=0.762$, $p<0.01$). Also, it showed a significant and positive correlation with BOD at CT5 ($r=0.589$, $p<0.05$). These results are different from those given byKhatoon[21].whose findings showed a significant negative correlation between DO and BOD.

Alkalinity

The presence of numerous ions leads to total alkalinity in water. The alkalinity values ranged from 33 to 93 mg/L, with an annual mean of63.97±15.022mg/L (Table 2, Figure 3.4). The maximum value was in Mar (AG5), and the minimum was at CT4 in Sep. The alkalinity was within the desirable ranges for aquaculture, which is 25-100mg/L[19].

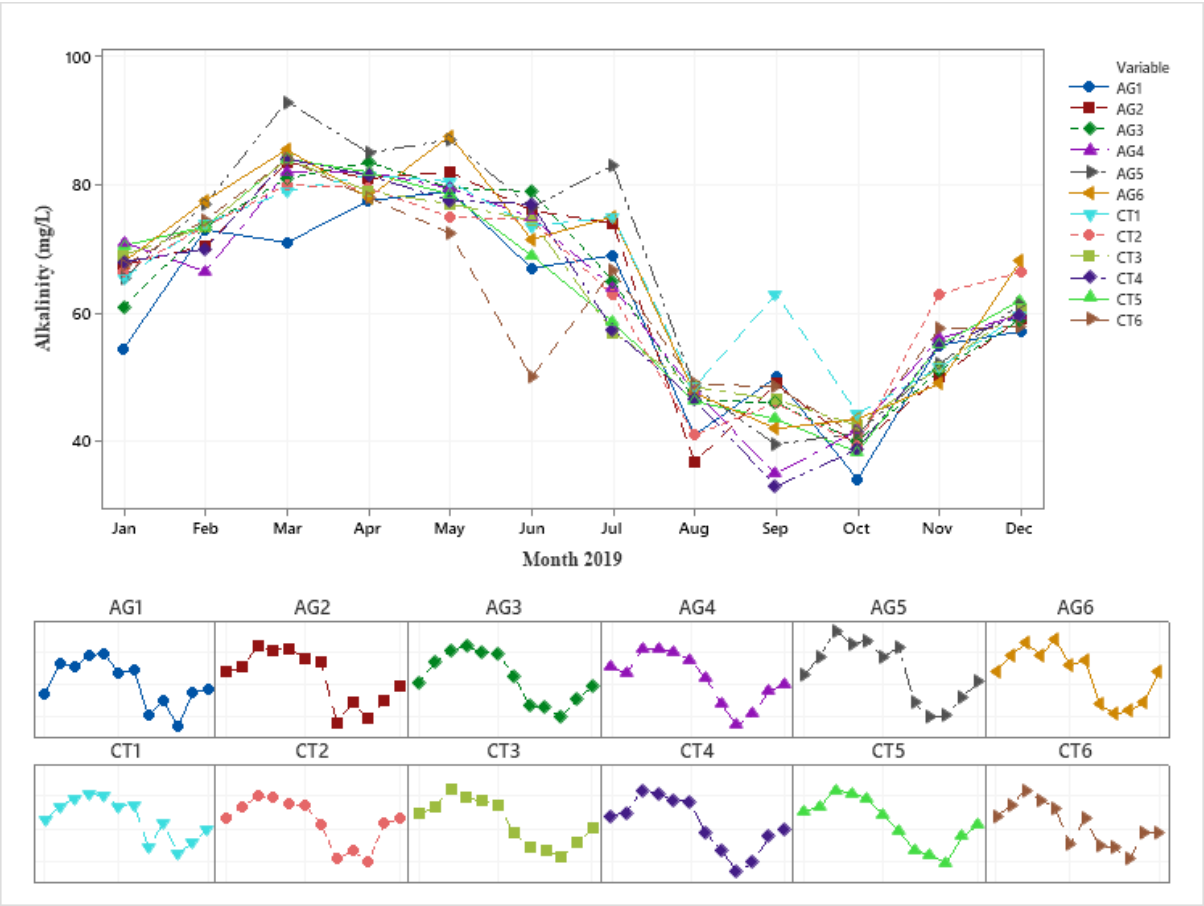

Figure 5 Graph showing the monthly variation of alkalinity for the sampled sites

Alkalinity showed positive and significant correlation with BOD (r=0.654, p<0.05), NO_3^-(r=0.617, p<0.05), and DO (r=0.736, p<0.05). It showed a highly significant and negative correlation with TSS. Alkalinity showed maximum correlation with Salinity at CT4 (r=0.693, p<0.05) and minimum at CT5 (r=0.634, p<0.05). Alkalinity versus Total Coliform showed a strong significant and negative correlation, which was maximum at CT4 (r=-0.779, p<0.01) and minimum at CT2 (r=0.697, p<0.05).

Salinity

During this study, the range of salinity varied from 49 to 223 mg/L. The minimum value was recorded at sampling site CT2 in October, and the maximum amount was recorded at AG6 (September) with an annual mean of 134.4±31.38mg/L (Table 2, Figure 3.5), which was within a desirable range for aquaculture[20].

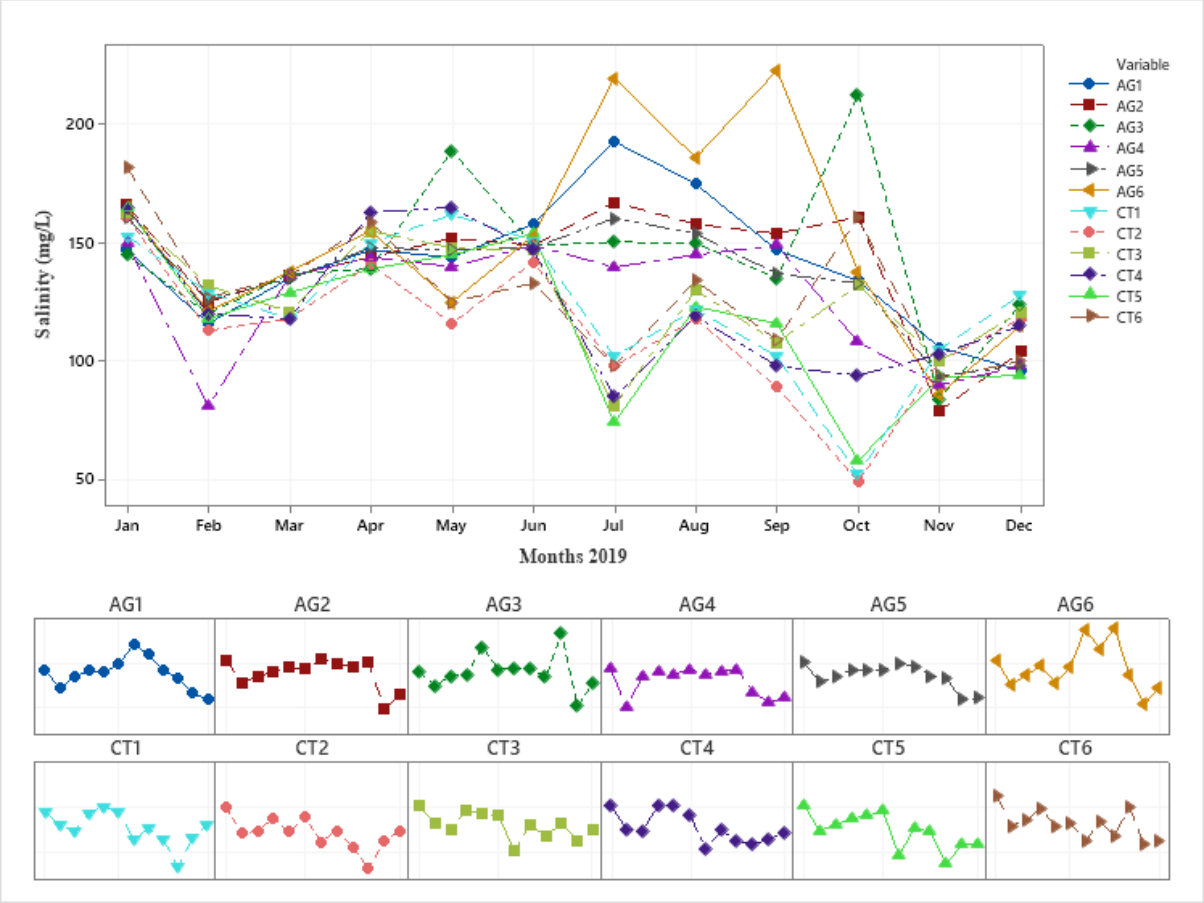

Figure 6 Graph showing the monthly variation of salinity for the sampled sites

In the present study, salinity has a significant and positive correlation with PO_4^{3-} ($r=0.613$, $p<0.05$) and strong significant negative correlation with TSS (-0.745, $p<0.01$). Salinity versus BOD showed a significant and negative maximum correlation at AG4 ($r=-0.749$, $p<0.01$) and minimum correlation at AG6 ($r=-0.698$, $p<0.05$).

TSS

The average value of TSS was observed as 38.73±21.61mg/L, and the ranges were detected as 5-104mg/L (Table 2, Figure3.6). These values were within the desirable ranges for aquaculture, according toPhilminaq[22]. Sampling site AG4 (Feb) had the lowest value while sampling site AG6 (July) had the highest value.

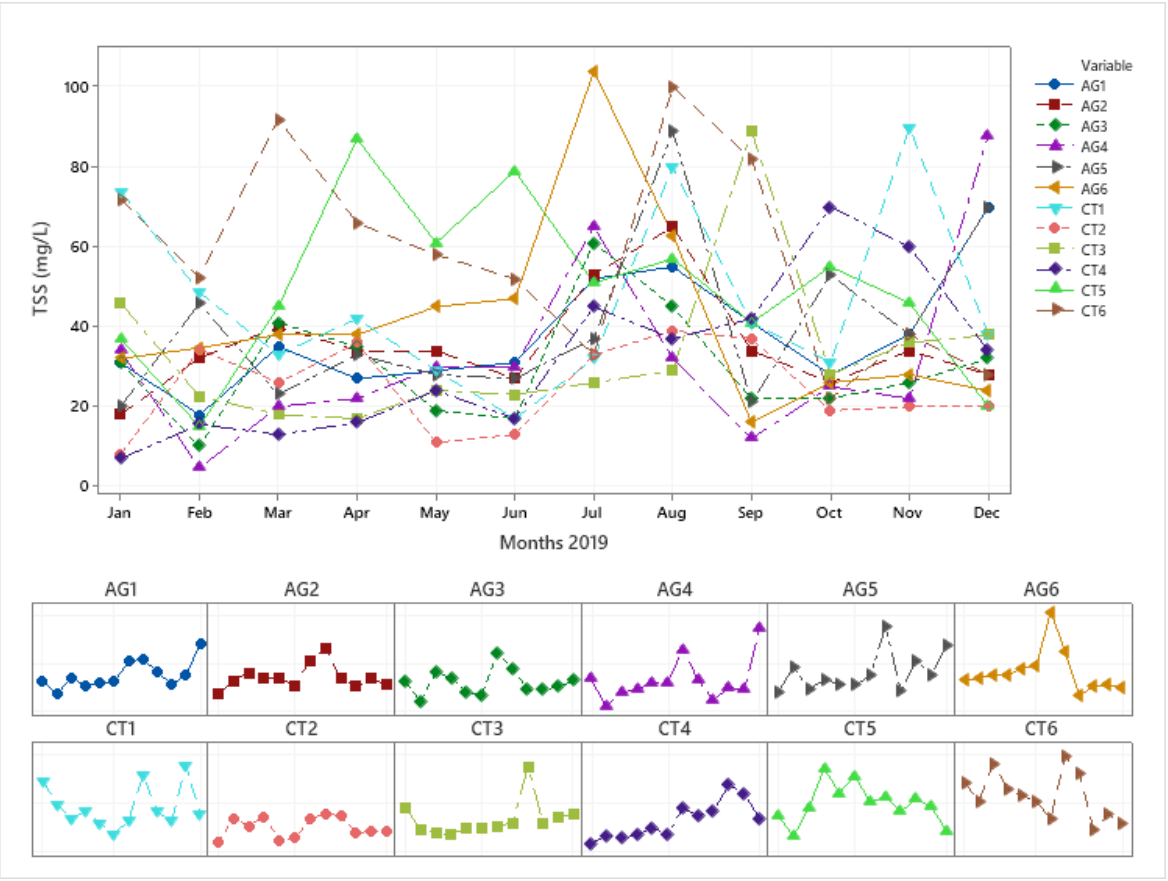

Figure 7 Graph showing the monthly variation of TSS for the sampled sites

The TSS showed a strong significant, and positive correlation with PO_4^{3-} ($r=0.797$, $p<0.01$). It showed maximum correlation with TAN at CT6 ($r=-0.658$, $p<0.05$) and minimum at CT1 ($r=0.637$, $p<0.05$).

TAN

The range of TAN varied from 0.005 to 0.865 mg/l in the study. The minimum value recorded was at AG2 (Sep), and the maximum value was recorded at CT6 (July) with an annual mean of 0.195± 0.1592 (Table 2, Figure 3.7), which was within the desirable ranges of aquaculture[20].

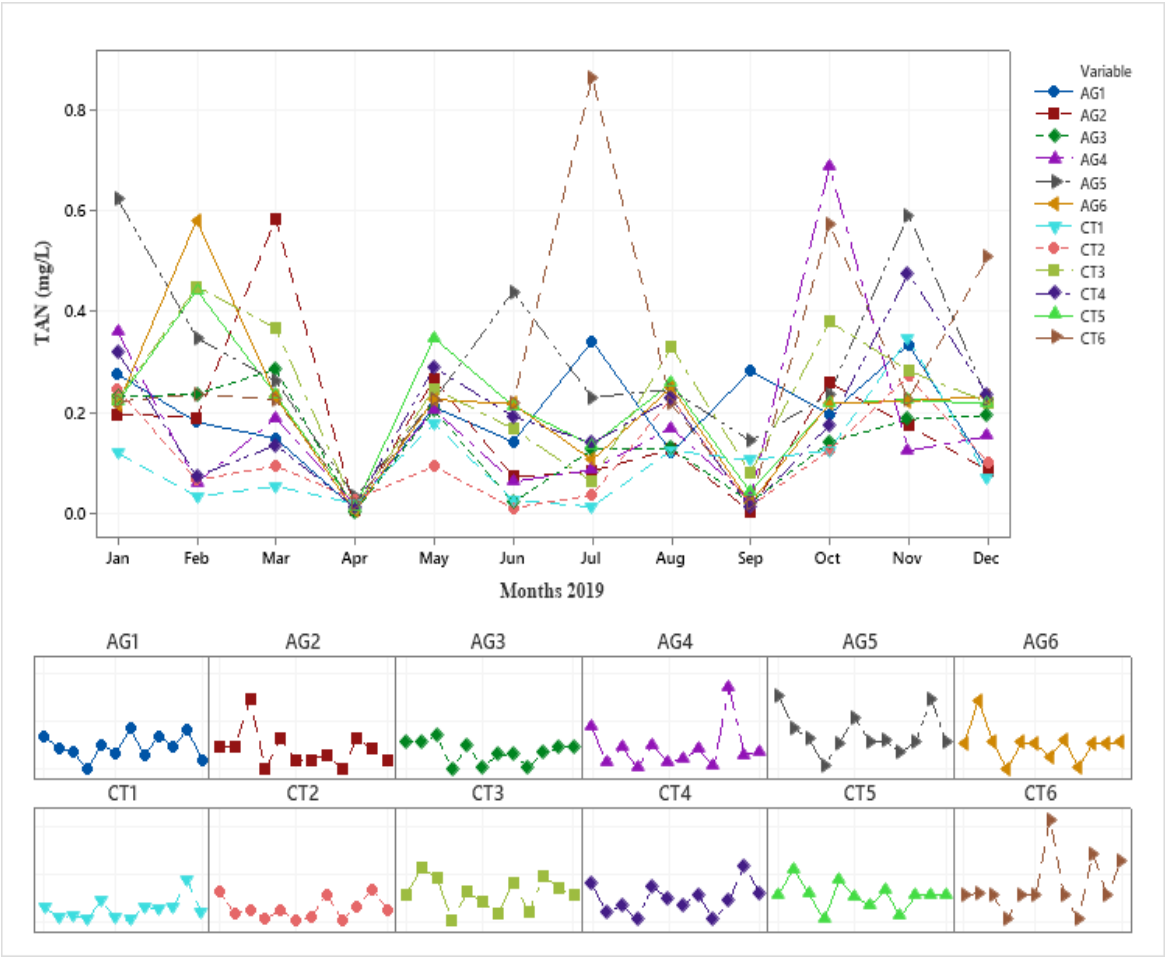

Figure 8 Graph showing the monthly variation of TAN for the sampled sites

TAN showed significant and positive correlation with BOD (r=0.647, p<0.05) and PO_4^{3-} (r=0.758, p<0.01). TAN also showed a significant and negative correlation with Total Coliform (r=-0.684).

BOD

During the study, the BOD values of Hau River ranged from 1.2 to 6.18 mg/L, with an annual mean of 3.439± 1.0525 (Table 2, Figure 3.8). The minimum value was recorded at AG3 (Nov), and the maximum value was recorded at CT3 (June), which was above the desirable range for aquaculture[19].

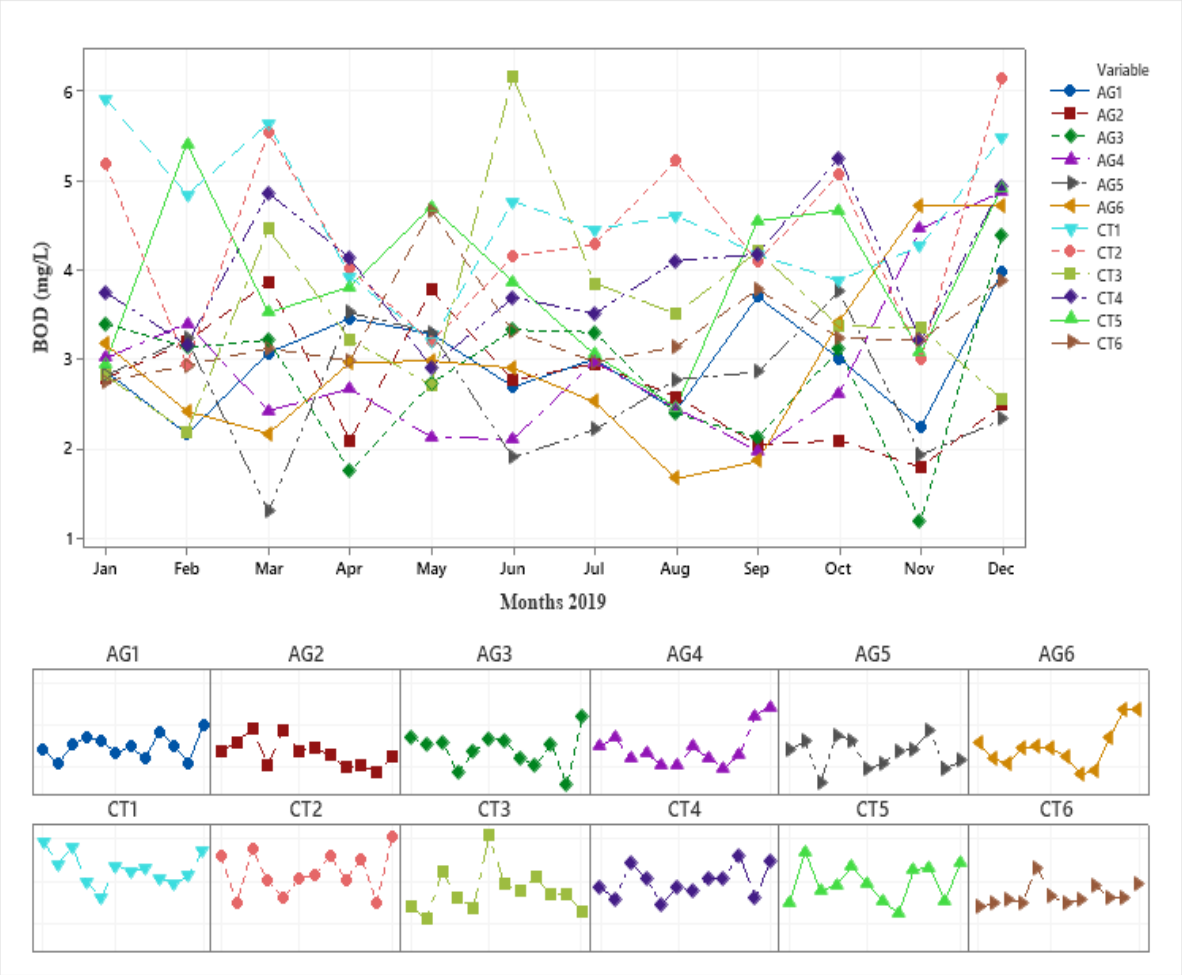

Figure 9 Graph showing the monthly variation of BOD for the sampled sites

The BOD showed a significant and positive correlation with PO_4^{3-} at AG1 ($r=0.642$, $p<0.05$).

Nitrate (NO_3^-)

The maximum nitrate level 0.489mg/L was recorded in AG5 (May), and the minimum value was 0.003mg/L in AG4 (Sep) in with an annual mean of 0.2198± 0.08218 (Table 2, Figure 3.9). Nitrate levels were within the desirable ranges for aquaculture, as prescribed byBhatnagar and Devi[19].

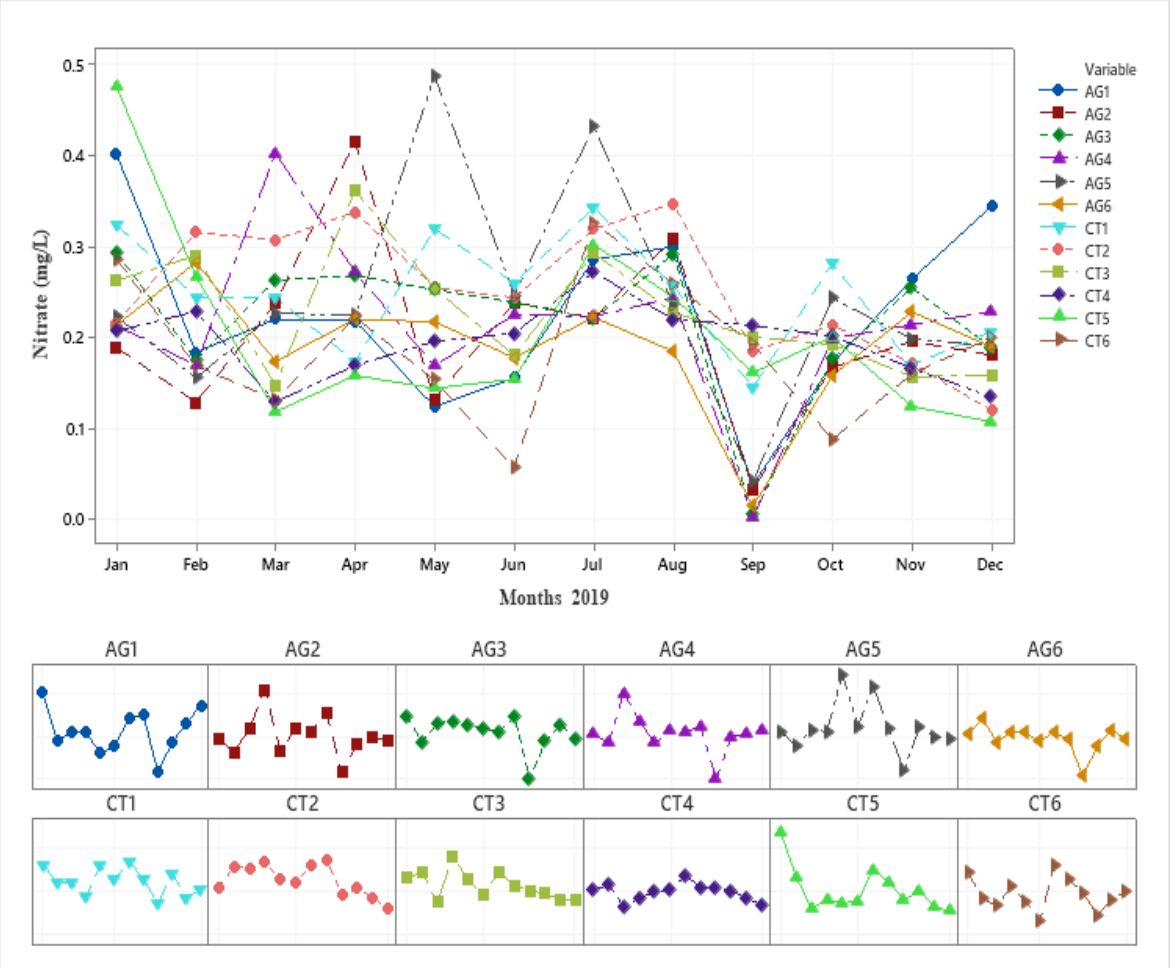

Figure 10 Graph showing the monthly variation of Nitrate for the sampled sites

The Nitrate showed a significant and negative correlation with Phosphate at CT4 ($r=-0.701$, $p<0.05$) and Total Coliform. Nitrate versus Total Coliform showed a maximum correlation at AG3 ($r=-0.706$, $p<0.05$) and minimum at AG4 ($r= -0.638$, $p<0.05$).

Phosphate (PO_4^{3-})

Phosphate is an important parameter in water quality assessment. In our study, the phosphate ranged from 0.005 to 0.6595mg/L. The minimum phosphate level was recorded both in AG1 (Feb) and AG4 (Nov), while the maximum was recorded in CT6 (Dec) with an annual mean of 0.184± 0.1614mg/L (Table 2, Figure 3.10). This was within the desirable ranges of aquaculture, as described by Kasnir[18].

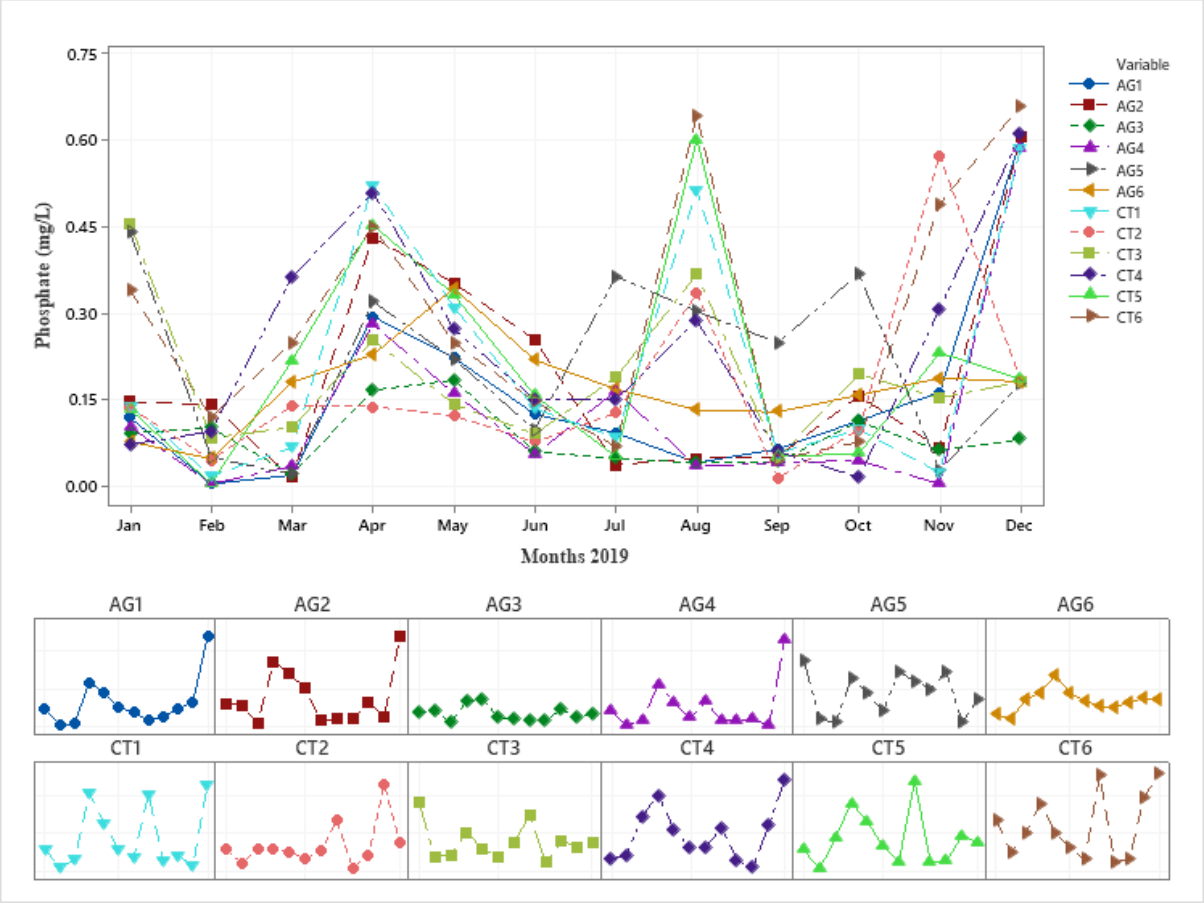

Figure 11 Graph showing the monthly variation of phosphate for the sampled sites

Phosphate versus temperature showed non-significant positive correlation maximum at AG6 (r=0.566, p>0.05) and minimum at CT6 (r=0.004, p>0.05). Phosphate versus Alkalinity showed non-significant positive correlation maximum at CT4 (r=0.396, p>0.05) and minimum at CT6 (r=0.026, p>0.05). Phosphate versus DO showed non-significant negative correlation maximum at CT1 (r=-0.507, p>0.05) and minimum at AG1 (r=-0.024, p>0.05). The non-significant correlation between phosphate and other parameters means that they are independent of each other.

Total Coliform (TC)

The range of total coliform varied from 0.45 to 150.0MPN×10^3/100ml in the study. The minimum value of total coliform was recorded in CT2 (Dec), and the maximum value was recorded at AG4 (May) with an annual mean of 23.7±30.29 MPN×10^3/100ml (Table 2, Figure 3.11), which was higher than the desirable range for aquaculture[22].

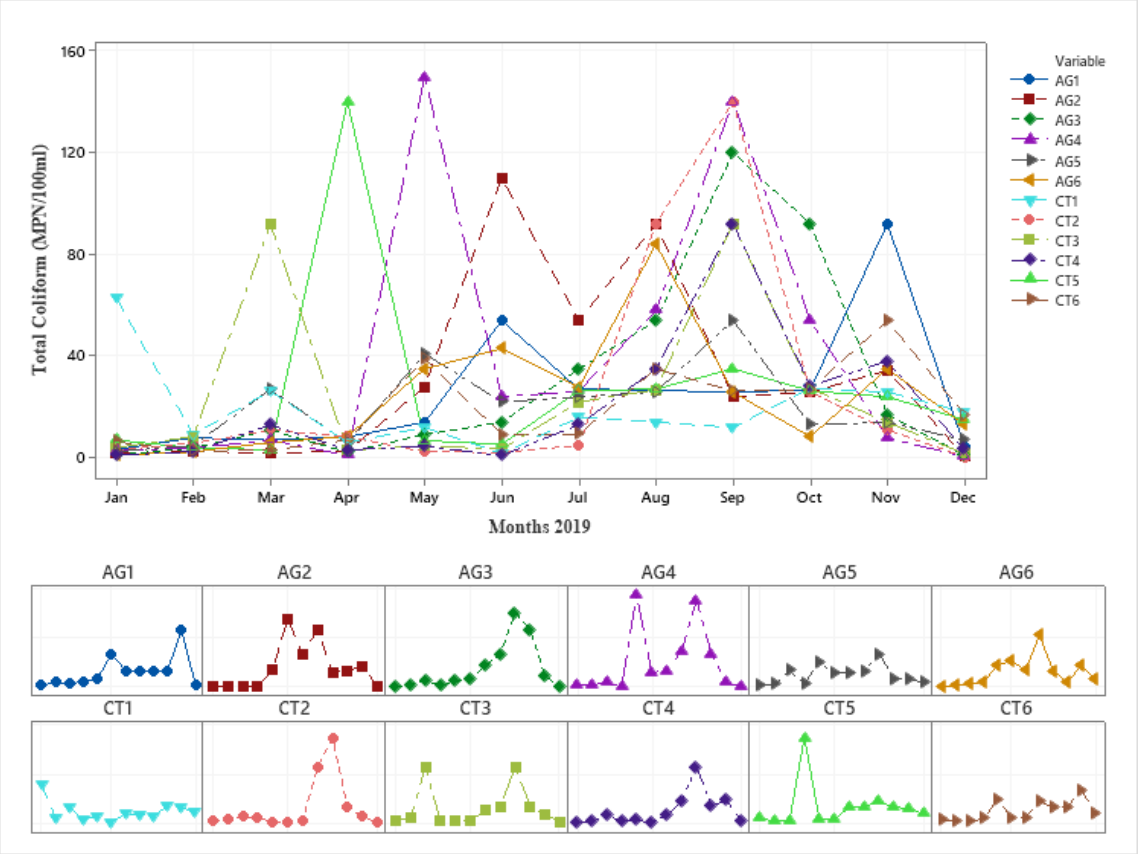

Figure 12 Graph showing monthly variation of Total Coliform for the sampled sites

Total Coliform versus Temperature showed non-significant positive correlation maximum at CT5 (r=0.472, p>0.05) and minimum at AG6 (r=0.024, p=>0.05). Total Coliform versus pH showed non-significant positive correlation maximum at CT6 (r=0.531, p>0.05) and minimum at AG4 (r=0.019, p>0.05). Total coliform versus Salinity showed non-significant correlation maximum at CT4 (r=-0.541, p>0.05) and minimum at CT5 (r=0.019, p>0.05). TC versus TSS showed non-significant positive correlation maximum at CT5 (r=0.559, p>0.05) and minimum at AG1 (r=0.004, p>0.05). The Total Coliform versus BOD showed non-significant negative correlation maximum at AG4 (r=-0.568, p>0.05) and minimum at AG2 (r=-0.08, p>0.05). Also, Total Coliform versus PO_4^{3-} showed non-significant correlation maximum at CT5 (r=0.426, p>0.05) and minimum at CT2 (r= -0.065, p>0.05). The non-significant correlation between the two parameters means that they are independent from each other.

V. Conclusion

From the current study, the surface water of Hau River had high levels of BOD and Total Coliform from An Giang to Can Tho Province, which was above the desirable ranges for aquaculture farming. The ecology of the river has a higher risk of pollutants from point sources. The correlation analysis of the water quality parameters revealed that all water quality parameters are correlated with each other either positively or negatively from the Pearson correlation matrix. Some water quality parameters like phosphate and Total Coliform did not have any significant correlation between them, which is an indication of different origin of the various sources of pollution. The values from the correlation matrix can be used in the selection of a few water quality parameters that can be measured frequently to determine the status of water quality regularly. This study will help the necessary management and regulatory bodies to take the control measures required to minimize Hau River's contamination.

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APPENDICES

Table 2 Pearson Correlations between the different parameters of surface water in Hau River at AG1 (VĩnhNgươn)

	Temp	pH	Alk	DO	Sal	TSS	TAN	BOD	NO3-	PO43-
pH	-0.263									
Alk	0.325	0.011								
DO	0.235	-0.305	0.53							
Sal	0.573	-0.111	0.023	0.109						
TSS	-0.175	0.581*	-0.315	-0.455	0.05					
TAN	-0.33	0.166	-0.188	0.165	0.158	-0.019				
BOD	0.216	-0.011	0.074	0.268	-0.088	0.397	-0.28			
NO3-	-0.438	0.338	-0.141	-0.424	-0.04	0.434	-0.018	-0.139		
PO43-	-0.146	0.409	0.097	-0.024	-0.466	0.512	-0.407	0.642*	0.306	
TC	-0.052	0.374	-0.231	-0.019	-0.066	0.004	0.441	-0.473	-0.129	-0.156

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

Table 3 Pearson Correlations between the different parameters of surface water in Hau River at AG2(Cầuchữ)

	Temp	pH	Alk	DO	Sal	TSS	TAN	BOD	NO^{3-}	PO_4^{3-}
pH	0.239									
Alk	0.374	-0.44								
DO	0.493	-0.068	0.258							
Sal	0.476	-0.304	0.079	0.262						

TSS	0.12	0.253	-0.2	0.268	0.169					
TAN	-0.024	-0.12	0.243	-0.111	-0.052	-0.022				
BOD	0.131	-0.492	0.654*	0.28	0.238	0.124	0.647*			
NO^{3-}	0.377	0.246	0.219	-0.326	0.051	0.328	-0.07	-0.091		
PO_4^{3-}	0.118	-0.031	0.26	-0.292	-0.239	-0.402	-0.318	-0.06	0.198	
TC	0.261	0.499	-0.228	0.245	0.254	0.46	-0.284	-0.08	0.191	-0.25

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

Table 4 Pearson Correlations between the different parameters of surface water in Hau River at AG3 (BếnđòRạchGọc)

	Temp	pH	Alk	DO	Sal	TSS	TAN	BOD	NO3	PO4
pH	0.157									
Alk	0.358	-0.016								
DO	0.049	0.326	0.142							
Sal	0.611*	-0.054	-0.07	0.191						
TSS	-0.028	-0.453	-0.053	0.102	-0.034					
TAN	-0.453	-0.492	0.07	0.001	-0.096	0.012				
BOD	-0.33	-0.021	0.138	0.372	0.285	0.068	0.355			
NO3	0.132	-0.682*	0.386	-0.478	0.002	0.331	0.332	0.003		
PO4	0.447	-0.13	0.344	-0.329	0.402	-0.381	-0.081	-0.114	0.179	
TC	0.16	0.388	-0.72**	0.273	0.347	-0.021	-0.417	-0.23	-0.706*	-0.29

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

Table 5 Pearson Correlations between the different parameters of surface water in Hau River at AG4 (BếnđòSơnĐốt)

	Temp	pH	Alk	DO	Sal	TSS	TAN	BOD	NO3	PO4
pH	0.077									
Alk	0.242	0.421								
DO	0.163	0.413	0.477							
Sal	0.277	0.146	0.196	-0.22						
TSS	-0.273	-0.104	0.019	-0.285	-0.027					
TAN	0.05	-0.698*	-0.275	-0.307	-0.13	0.017				
BOD	-0.619*	-0.004	-0.073	-0.03	-0.749**	0.5	-0.042			
NO3	0.108	0.207	0.617*	0.326	0.01	0.172	0.096	0.13		
PO4	-0.147	-0.002	0.181	-0.256	-0.096	0.797**	-0.129	0.5	0.112	
TC	0.305	0.019	-0.347	-0.304	0.359	-0.219	0.04	-0.568	-0.638*	-0.195

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

Table6 Pearson Correlations between the different parameters of surface water in Hau River at AG5 (KênhTây An)

	Temp	pH	Alk	DO	Sal	TSS	TAN	BOD	NO3	PO4
pH	0.42									
Alk	0.476	0.516								
DO	0.15	0.028	0.264							
Sal	0.423	0.018	0.295	0.008						
TSS	-0.269	-0.488	-0.401	-0.249	-0.24					
TAN	-0.559	0.393	-0.115	0.022	-0.164	-0.19				
BOD	0.071	-0.443	-0.254	0.33	0.219	0.164	-0.367			

NO3	0.354	0.34	0.541	-0.043	0.395	-0.046	-0.061	0.033		
PO4	-0.052	-0.573	-0.244	-0.032	0.613*	0.09	-0.199	0.554	0.231	
TC	0.308	0.11	-0.125	-0.463	0.212	-0.239	-0.349	-0.115	0.09	-0.066

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

Table 7 Pearson Correlations between the different parameters of surface water in Hau River at AG6 (KênhCái Sao 2)

	Temp	pH	Alk	DO	Sal	TSS	TAN	BOD	NO3	PO4
pH	0.092									
Alk	0.32	-0.447								
DO	0.554	0.108	0.539							
Sal	0.088	0.052	-0.202	0.183						
TSS	0.247	0.013	0.29	0.147	0.469					
TAN	-0.373	0.033	0.197	0.083	-0.513	-0.09				
BOD	-0.329	0.038	-0.063	-0.49	-0.698*	-0.339	0.032			
NO3	0.021	-0.034	0.547	0.231	-0.53	0.333	0.569	0.3		
PO4	0.566	-0.162	0.365	-0.091	-0.224	0.116	-0.396	0.222	0.012	
TC	0.024	0.072	-0.344	-0.393	0.243	0.395	-0.094	-0.27	-0.134	0.225

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

Table8 Pearson Correlations between the different parameters of surface water in Hau River at CT1(Cái Cui)

	Temp	pH	Alk	DO	Sal	TSS	TAN	BOD	NO3	PO4
pH	0.211									
Alk	0.114	0.16								
DO	0.203	0.245	0.736**							
Sal	0.043	-0.244	0.647*	0.451						
TSS	0.087	-0.448	-0.51	-0.091	-0.008					
TAN	0.424	0.086	-0.525	-0.152	-0.175	0.637*				
BOD	-0.341	0.008	-0.002	0.132	0.154	0.198	-0.272			
NO3	-0.186	0.384	0.165	-0.039	0.109	-0.199	-0.201	0.073		
PO4	-0.12	-0.641*	-0.027	-0.507	0.37	0.036	-0.167	-0.048	-0.128	
TC	-0.041	0.113	-0.277	0.021	-0.073	0.469	0.303	0.523	0.335	-0.225

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

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

Table 9 Pearson Correlations between the different parameters of surface water in Hau River at CT2 (CồnKhương)

	Temp	pH	Alk	DO	Sal	TSS	TAN	BOD	NO3	PO4
pH	0.166									
Alk	0.157	-0.055								
DO	-0.458	0.12	-0.111							
Sal	-0.183	-0.568	0.637*	-0.162						
TSS	-0.034	-0.104	-0.261	0.289	-0.232					
TAN	-0.388	-0.085	-0.294	-0.245	0.074	-0.284				
BOD	-0.258	-0.384	-0.24	0.337	0.057	-0.073	0.127			
NO3	0.384	-0.235	0.2	-0.212	0.2	0.521	-0.197	-0.174		
PO4	-0.165	0.088	-0.137	-0.396	-0.019	-0.041	0.758**	-0.108	-0.155	
TC	-0.105	-0.114	-0.697*	0.338	-0.32	0.552	-0.034	0.065	-0.024	-0.065

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

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

Table10 Pearson Correlations between the different parameters of surface water in Hau River at CT3 (ThuậnHưng)

	Temp	pH	Alk	DO	Sal	TSS	TAN	BOD	NO3	PO4
pH	0.412									
Alk	0.312	-0.112								
DO	0.189	0.636*	0.361							
Sal	0.183	-0.605*	0.501	-0.495						
TSS	-0.449	-0.059	-0.525	-0.112	-0.239					
TAN	-0.142	-0.299	-0.022	-0.237	0.092	-0.298				
BOD	0.427	0.375	0.059	0.551	-0.103	0.035	-0.286			
NO3	0.125	-0.039	0.281	-0.202	0.292	-0.228	-0.389	-0.364		
PO4	-0.297	-0.34	-0.109	-0.459	0.404	-0.094	-0.04	-0.322	0.323	
TC	0.164	0.301	-0.147	0.459	-0.396	0.463	0.041	0.352	-0.39	-0.381

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

Table11 Pearson Correlations between the different parameters of surface water in Hau River at CT4 (BếnphàTràUối)

	Temp	pH	Alk	DO	Sal	TSS	TAN	BOD	NO3	PO4
pH	-0.522									
Alk	0.287	-0.637*								
DO	-0.016	-0.148	-0.367							
Sal	0.206	-0.486	0.693*	-0.414						
TSS	0.02	0.614*	-0.78**	0.122	-0.745**					
TAN	-0.387	0.497	-0.008	-0.545	0.089	0.243				
BOD	0.043	0.35	-0.277	0.427	-0.313	0.235	-0.29			
NO3	-0.013	-0.193	-0.339	-0.052	-0.209	0.147	-0.192	-0.462		
PO4	-0.012	0.223	0.396	-0.378	0.215	-0.187	0.078	0.216	-0.701*	
TC	-0.063	0.346	-0.779**	0.572	-0.541	0.529	-0.162	0.145	0.133	-0.312

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

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

Table 12 Pearson Correlations between the different parameters of surface water in Hau River at CT5 (SôngCáisắn- Vĩnh Trinh)

	Temp	pH	Alk	DO	Sal	TSS	TAN	BOD	NO3	PO4
pH	0.446									
Alk	0.16	0.13								
DO	0.577*	0.574	0.028							
Sal	-0.249	-0.369	0.634*	-0.19						
TSS	0.54	-0.152	0.134	0.206	0.265					
TAN	-0.164	0.073	0.199	-0.044	0.082	-0.468				
BOD	0.352	0.454	0.084	0.589*	-0.153	-0.347	0.29			
NO3	-0.604*	-0.249	-0.037	-0.506	0.212	-0.212	0.118	-0.35		
PO4	0.255	-0.071	0.149	0.028	0.336	0.505	-0.1	-0.466	-0.202	
TC	0.472	0.131	0.112	0.435	0.019	0.559	-0.684*	-0.098	-0.155	0.426

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

Table 13 Pearson Correlations between the different parameters of surface water in Hau River at CT6 (ThạnhMỹ-VĩnhThạnh)

	Temp	pH	Alk	DO	Sal	TSS	TAN	BOD	NO3	PO4
pH	0.207									
Alk	0.267	-0.63*								
DO	-0.083	0	-0.382							
Sal	0.12	-0.077	0.116	-0.462						
TSS	-0.04	0.151	0.249	-0.517	0.281					
TAN	-0.077	0.136	-0.166	0.038	-0.273	-0.658*				
BOD	0.271	0.177	-0.115	0.392	-0.375	-0.1	-0.091			
NO3	-0.095	0.042	0.227	-0.383	-0.045	0.185	0.24	-0.292		
PO4	0.004	0.065	0.026	0.258	-0.063	0.156	-0.174	0.034	0.261	
TC	0.111	0.531	-0.467	0.762**	-0.39	-0.108	-0.085	0.472	-0.127	0.298

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

Fridah Gacheri Mutea, et. al. " Evaluation of Water Quality for Aquaculture: Physico – Chemical Characteristics of Hau River (Mekong Delta)with reference to Correlation Study." *IOSR Journal of Applied Chemistry (IOSR-JAC)*, 13(7), (2020): pp 33-50.