



Contents lists available at ScienceDirect

Saudi Journal of Biological Sciences

journal homepage: www.sciencedirect.com

Original article

The impact of water quality on the Asian clam, *Corbicula fluminea*, distribution in Pergau Lake, Kelantan, MalaysiaAweng Eh Rak^a, Zulhisyam Abdul Kari^b, Mohd Zharif Ramli^b, Hasnita Che Harun^b, Suniza Anis Mohamad Sukri^b, Hazreen Nita Mohd Khalid^b, Faizuan Abdullah^c, Mahmoud A.O. Dawood^{d,e}, Wendy Wee^f, Lee Seong Wei^{b,*}^a Faculty of Earth Science, Universiti Malaysia Kelantan Jeli Campus, 17600 Jeli, Kelantan, Malaysia^b Department of Agricultural Sciences, Faculty of Agro-Based Industry, Universiti Malaysia Kelantan, Jeli Campus, 17600 Jeli, Kelantan, Malaysia^c Department of Chemistry, Faculty of Science, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia^d Department of Animal Production, Faculty of Agriculture, Kafrelsheikh University, 33516 Kafrelsheikh, Egypt^e The Center for Applied Research on the Environment and Sustainability, The American University in Cairo, 11835 Cairo, Egypt^f Center of Fundamental and Continuing Education, Universiti Malaysia Terengganu, 21030 Kuala Nerus, Terengganu, Malaysia

ARTICLE INFO

Article history:

Received 22 November 2021

Revised 1 December 2021

Accepted 4 December 2021

Available online 13 December 2021

Keywords:

Conservation

Asian Clam

Distribution

Water quality

Malaysia

ABSTRACT

In the present study described the impact of water quality on the Asian clam, *Corbicula fluminea*, distribution in man – made Pergau Lake was carried out. Recently, Pergau Lake was gazetted as state park and any activities related to fishery and agricultural were not allowed in the park. Subsequently, the nearby lake community was affected as many of them earn a living by carrying fisheries activity in the lake especially harvesting Asian clam. 10 sampling sites were selected in the lake to monitor water quality and Asian clam distribution. Water parameters data were also subjected to cluster analysis by using Ward's method with squared Euclidean distances as a measure of similarity and a dendrogram was successfully generated. The water quality of the lake is under good condition and suitable to carry fishery activities by referred to Malaysia National Water Quality Standards (NWQS). The dendrogram revealed that the sampling sites can be divided into 2 clusters where Location 1 alone in its own cluster. Another cluster possesses 2 sub-clusters where Location 2 and 3 shared similar sub cluster. Another sub-cluster has two groups namely Location 5, 6 and 8 in one group whereas Location 4, 7, 9 and 10 shared similar group. The findings of the present study showed most of sampled Asian clam in Pergau Lake was semi mature indicating highly exploitation of Asian clam in the Lake. Furthermore, there were no correlation was detected between the population of Asian clam and water quality of the lake. Hence, we suggest that seasonal harvesting Asian clam should be implemented in order to conserve the population of Asian clam in the lake at the mean time the community to continue earn a living through carrying fishery activities in the lake.

© 2021 The Author(s). Published by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

* Corresponding author at: Faculty of Agro Based Industry, Universiti Malaysia Kelantan, Jeli Campus, 17600 Jeli, Kelantan, Malaysia.

E-mail address: leeseong@umk.edu.my (L.S. Wei).

Peer review under responsibility of King Saud University.



<https://doi.org/10.1016/j.sjbs.2021.12.008>

1319-562X/© 2021 The Author(s). Published by Elsevier B.V. on behalf of King Saud University.

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

Asian clam or *Corbicula fluminea* is a famous freshwater clam in which reported as invasive species and pest in many countries. For instance, Novais et al. (2017) in Portugal this invasive clam becomes problem to ecosystem. Similar case was also reported in America where this exotic clam posed an impact to lake ecosystem (Beaver et al., 1991). However, Asian clam is economic important aquatic species in China (Chen et al., 2013) and it became famous delicacy in Malaysia especially in Kelantan. Kelantanese prefer smoked Asian clam as a past time snack (Lee et al., 2013). The demand of aquaculture product (Zulhisyam et al., 2022) including of Asian Clam in Kelantan is increase rapidly until the population of

this clam in the wild was fully exploited by local harvester. Subsequently, smoked Asian clam retailer has to outsource from nearby countries to fulfil market demand.

Asian clam from Cambodia, Thailand and Vietnam were imported to Kelantan at the price of USD 3 per kg. The price is expected sky rocket during festival celebration in Kelantan. However, Kelantanese prefer local Asian clam as its claimed possess high fat and tasty compared to import one (Ramli et al., 2021). Hence local Asian clam has good price. Due to the fact, local Asian clam harvester is continuing hunting local Asian clam from wild. Thus, local Asian clam population vanish and claimed to be extinct. One of the famous location for local Asian clam harvesting activity is Pergau Lake. Pergau lake is one of the hot spot for tourist where attracted 30,000 visitors annually. This man-made lake becomes water reservoir for whole Kelantan residents' consumption too. Besides that, community around Pergau Lake carrying fisheries activity including harvesting Asian clam for own uses and selling. The impact of the Pergau Lake is huge as some of the residents were fully depend on this lake to gain an earning. However, the recent new regulation has been set where Pergau Lake has been gazetted as free fishery activity zone in order to conserve the biodiversity in the Pergau Lake. Subsequently, the nearby residents have suffered a lot where they lost their solely income. Therefore, in the present study was carried out to monitor Asian clam distribution in Pergau Lake and suggest to authority to allow seasonal Asian clam harvesting activity.

2. Materials and methods

2.1. Study area

The study location was at the man-made Pergau Lake located on the border of Perak – Kelantan state of Peninsular of Malaysia. This man – made lake with the size 460 ha was built with the purpose to generate hydroelectric for domestic uses. In the present study, a total of ten stations was selected and marked by using Global Positioning System (GPS) (Fig. 1) (Table 1). The locations were selected with the advice from local Asian clam collector and Malaysian Fishery Officer. Table 2.

2.2. Water sampling and analysis

In the present study, YSI Multiparameter (YSI, US) was used to measure three in-situ parameters such as temperature, dissolve oxygen and pH. There are three parameters (biological oxygen demand (BOD₅), chemical oxygen demand (COD), total suspended solid (TSS) were analyzed by using water sample collected from the field. The BOD₅ measurement was followed as described in the study of Klein and Gibbs (1979). Laboratory measurement for total suspended solid (TSS) and chemical oxygen demand (COD) were analysed by using Spectrophotometer model DR5000 or DR 2800 (Hach, Canada) with a different method for the different parameter (Hach, 2007). BOD₅ was measured by using the HACH LhDO dissolve oxygen probe. Photometric method used for TSS, dilution method used for BOD, and reactor digestion method used for COD. The sample was added to some base solution to neutralize the preservative before the samples were analyzed except for BOD₅ and TSS. Total ammonia in the samples was measured as described by Sriyasa et al. (2015). At the meantime, heavy metal parameters (Cr, Cu, K, Mg, Ni, Pb, and Zn) were measured by using Atomic Absorption Spectroscopy (AAS) PinAAcle 900F (Perkin Elmer, UK) for 10 samples of water and 5 samples of sediment. The sample was prepared by using Extraction Procedure and Extractable Cations method for water and soil sample respectively. In additional, the organic matter in soil also measured by using

Loss on Ignition (LOI). The soil sample was ignited in temperature of 400 °C for more than 3 h in muffle furnace. Next the organic content measured by calculating the percentage of different weight of dry and burn soil ratio to dry soil. The results of the water quality were compared to Malaysia water quality standards (2008) (Table 3).

2.3. Asian clam sampling

The study was conducted in February to August 2020. A grab sampler (Ekman Sediment Grab Sampler) was used to collect the sediment samples that contain Asian clam. The samples were then placed into zipper bags and stored in the ice box until further processed at the lab. Each of zipper bag is visually inspected for the present of invertebrates. They were removed gently from the sediment samples by using forceps. Asian clam (*Corbicula fluminea*), mussel (*Pilsbryconcha exilis*) and other snails (gastropods) were found in the sediments. Some invertebrates were stored in 70% ethanol and counted. This work was carried out on the same day since to minimize the mortality and damage to biota. The Asian clam distribution and density of each sampling station were determined by counting per sampling sample.

2.4. Asian clam identification and its age determination

Two morphometric characteristics namely shell length (SL) (the longest distance from the anterior to posterior edge) and shell height (SH) (the longest distance from the umbo or shell hinge to the edge of the shell opening) was measured for each clam by using vernier calipers (0.01 mm). These data were transformed to natural log to minimize the environmental influences. The age of the Asian clam was determined based on SL and SH transformed data. All cohorts were assigned according to respective classes of age. The samples were then further identified via 16S DNA sequencing and deposited into National Center for Biotechnology Information (NCBI). The samples were identified as *Corbicula fluminea* (MF 319,222 and MF 319223).

2.5. Data analysis

Water and soil quality data from 10 stations were recorded and summarised. The water and soil parameters as well as Asian clam distribution and density were subjected to pearson correlation matrix was analysed by SPSS version 23 followed by hierarchical cluster analysis by using Ward's method with squared Euclidean distances as a measure of similarity. In the present study Ward's method was used ANOVA followed by Tukey post hoc ($p < 0.05$) in order to minimize the sum of squares. The result was represented by a dendrogram.

3. Results

In the present study was successfully revealed water quality of 10 locations at Pergau Lake, Malaysia (Table 4). pH values of 10 locations were ranging 7.49 to 10.20 whereas Dissolved Oxygen (DO) was ranged from 7.73 to 9.53 ppm. The highest total suspended solid (TSS) among sampling locations was Location 1 (0.061 ppt) whereas the lowest was Location 5 (0.007 ppt). In terms of biological oxygen demand (BOD), Location 3 showed the highest (1.44 ppm) whereas Location 7 possess the lowest one (0.02 ppm). On the other hand, Location 1 has the highest chemical oxygen demand (COD) (41.1 ppm) and the lowest COD value was recorded in Location 3. Temperature among the sampling sites was ranged from 22.9 °C (Location 5) to 27.9 °C (Location 2). Heavy metals like Cadmium (Cd), Nickel (Ni), Cooper (Cu) and Chromium



Fig. 1. Study area in Pergau Lake.

Table 1
GPS position of sampling locations in study area.

Location	GPS position
1	N 5°61'87.57", E 101°70'49.63"
2	N 5°61'81.30", E 101°68'08.55"
3	N 5°60'20.18", E 101°68'72.13"
4	N 5°60'68.67", E 101°68'28.20"
5	N 5°59'60.34", E 101°68'97.26"
6	N 5°61'23.48", E 101°68'98.52"
7	N 5°61'40.56", E 101°69'57.91"
8	N 5°62'17.03", E 101°68'97.42"
9	N 5°61'83.58", E 101°69'68.46"
10	N 5°62'91.59", E 101°68'60.53"

(Cr) were absent in all sampling locations (Table 4). On the other hand, Plumbum (Pb) was detected in all locations except Location 6, 7, and 8 with the range from 0.01 to 0.42 ppm. At the meantime, Zinc (0.01 to 0.16 ppm), Magnesium (0.21 to 0.41 ppm) and Kalium (1.36 to 2.15 ppm) were found in all sampling locations. Based on water parameters of 10 sampling location revealed that the sampling sites can be divided into 2 clusters where Location 1 alone in its own cluster (Fig. 2). Another cluster possesses 2 sub clusters where Location 2 and 3 shared similar sub cluster. Another sub cluster has two groups namely Location 5, 6 and 8 in one group whereas Location 4, 7, 9 and 10 shared similar group. Soil parameters of 5 sampling locations showed no heavy metals like Cd, Cr

and Ni. Cu was only found in Location 1 (0.02 ppm), Location 2 (0.08 ppm), Location 3 (0.05 ppm) but absent in Location 4 and 5 (Table 5). Pb was found in Location 2 to 5 but absent in Location 1 with the range from 0.22 to 0.40 ppm. Mg showed the highest concentration among heavy metals with the range from 0.85 to 11.69 ppm. This was followed by K (2.13 to 8.03 ppm) and Zn (0.08 to 0.22 ppm). Location 2 possesses the highest density of Asian clam (113.63 piece / m²) (Table 6). This was followed by Location 1 (50.46 piece / m²), 4 (15.29 piece / m²) and 5 (2.21 piece / m²). Asian clam was absent in Location 3. Overall the Asian clam survival rate of the sampling sites was high ranging from 87.95 to 100 %. Only Location 5 perform lowest survival rate of Asian clam in the present study. Majority of sampled Asian clam was semi maturity and only mature Asian clam was found in Location 4 (28.6%). Juvenile and young Asian clam was minority in the sampling sites in which less than or equivalent 25 % or none. Table 7 showed significance positive correlation was found between Pb and TDS, Asian clam density and Cr, the presence of juvenile Asian clam and Asian clam survival rate and the presence of juvenile and young Asian clam. The presence of K in the soil was found significance positive correlation with the presence of Cu and Mg (Table 8).

4. Discussion

The finding of the present study revealed that the water quality of Pergau Lake is categorised as II class based on Malaysia National

Table 2
The water quality parameters and analytical methods in the present study.

Parameters	Analytical method	Unit
Salinity	Salinity probe	ppt
pH	pH probe	–
Dissolved oxygen	Oximeter	mg/L
Turbidity	Turbidimetry	NTU
Ammonia	Spectrophotometry	mg/L
Total suspended solid	Gravimeter	mg/L
Biological oxygen demand	BOD	mg/L
Chemical oxygen demand	COD	mg/L
Temperature	Temperature probe	°C
Cd, ppm	Atomic Absorption Spectroscopy (AAS) PinAAcle 900F	ppm
Cr, ppm	Atomic Absorption Spectroscopy (AAS) PinAAcle 900F	ppm
Cu, ppm	Atomic Absorption Spectroscopy (AAS) PinAAcle 900F	ppm
Ni, ppm	Atomic Absorption Spectroscopy (AAS) PinAAcle 900F	ppm
Pb, ppm	Atomic Absorption Spectroscopy (AAS) PinAAcle 900F	ppm
Zn, ppm	Atomic Absorption Spectroscopy (AAS) PinAAcle 900F	ppm
Mg, ppm	Atomic Absorption Spectroscopy (AAS) PinAAcle 900F	ppm
K, ppm	Atomic Absorption Spectroscopy (AAS) PinAAcle 900F	ppm

Table 3
Malaysia National Water Quality Standards (NWQS).

Parameter	Unit	Class						
		I	IIA	IIB	III	IV	V	
Dissolved Oxygen	mg/l	7	5–7	5–7	3–5	< 3	< 1	
pH	–	6.5–8.5	6–9	6–9	5–9	5–9	–	
Electrical Conductivity*	µS/cm	1000	1000	–	–	6000	–	
Total Dissolved Solid	mg/l	500	1000	–	–	4000	–	

Table 4
Water quality of 10 locations at Pergau Lake, Kelantan, Malaysia.

Water Parameter	Location 1	Location 2	Location 3	Location 4	Location 5	Location 6	Location 7	Location 8	Location 9	Location 10
pH	8.79	8.58	8.74	8.51	9.66	10.20	7.49	8.61	9.02	9.01
Dissolved oxygen, ppm	8.33	8.65	9.53	8.52	7.86	8.59	7.73	8.51	8.65	8.58
Total suspended solid, ppt	0.061	0.009	0.011	0.017	0.007	0.013	0.011	0.017	0.016	0.015
Ammonia, mg/L	0.02	0.08	0.07	0.11	0.06	0.08	0.08	0.027	0.12	0.023
Biological oxygen demand, ppm	1.20	1.00	1.44	0.80	0.24	0.59	0.02	0.64	0.76	0.36
Chemical oxygen demand, ppm	41.1	19.7	17.9	33.9	27.5	25.1	31.7	25.7	28.9	30.7
Temperature, °C	27.0	27.9	27.6	27.3	22.9	27.3	27.5	27.6	27.6	27.4
Cd, ppm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cr, ppm	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cu, ppm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ni, ppm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pb, ppm	0.42	0.08	0.02	0.01	0.02	0.00	0.00	0.00	0.28	0.26
Zn, ppm	0.01	0.02	0.01	0.02	0.16	0.04	0.03	0.01	0.16	0.02
Mg, ppm	0.29	0.38	0.38	0.30	0.41	0.35	0.32	0.37	0.30	0.21
K, ppm	1.74	2.06	2.07	1.72	1.98	1.88	1.84	2.15	1.55	1.36

Water Quality Standards (NWQS) where the water is suitable for domestic uses, agricultural and fishery activities. Temperature among sampling sites do not have huge difference. Temperature reading is influenced by weather, sampling time and location (Suhaimi-Othman et al., 2007). The temperature value will effect on DO, biological activities and other water parameters. However, in the present study, temperature records showed no correlation with other water parameters. DO values of the sampling sites indicating the lake is healthy and can support aquatic animal needs including Asian clam where it's only can survive at high DO level environment. Raining and high of wind velocity were identified as factors that can contribute to high level of DO in the aquatic

environment (Gadhia et al., 2012; Saiful Islam et al. 2015). The presence of photosynthetic phytoplankton may also lead to higher value of DO in the water system (Sharma and Rathore, 2000; Ravindra et al., 2003). On the other hand, the presence organic matter will lead to depletion of DO level in the water (Astel et al., 2006). In the present study, Location 1 possesses the highest organic matter in the soil. However, DO level in the Location 1 is still optimum for aquatic animals to live. High DO level in the water system can promote the conversion ammonia NH₃ to nitrate NO₄ and absorbed by phytoplankton and aquatic plant. This was supported by the finding of the present study where the low level of ammonia was observed in the Pergau Lake. The highest value of

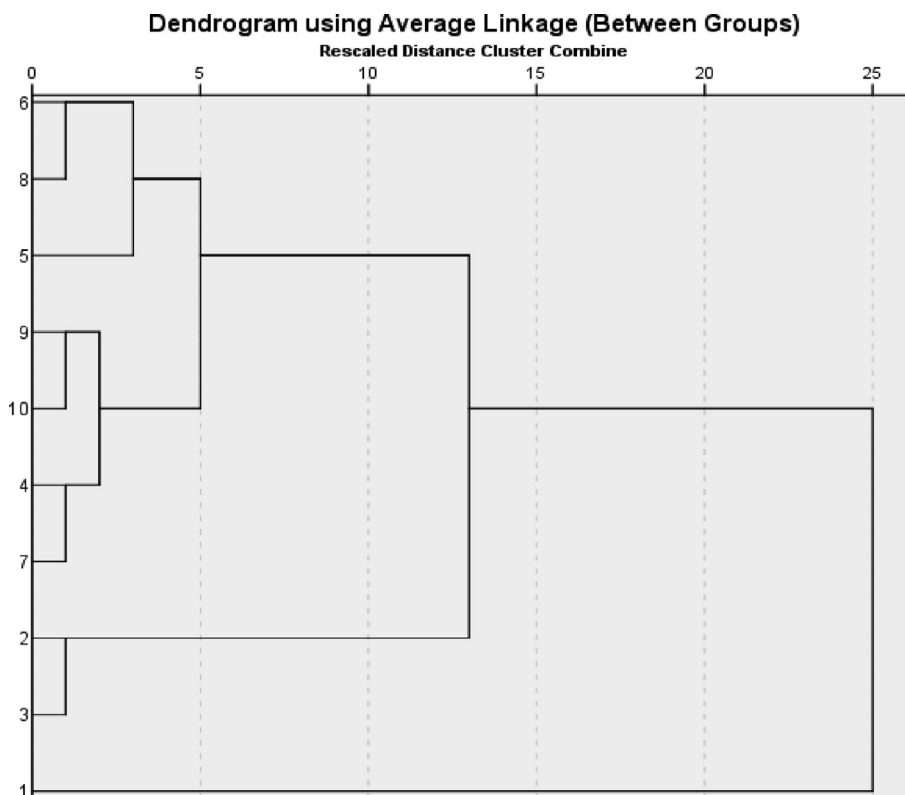


Fig. 2. Dendrogram based on 10 locations water quality at Pergau Lake using Ward Linkage.

Table 5
Soil parameters of 5 locations at Pergau Lake, Kelantan, Malaysia.

Water Parameter	Location 1	Location 2	Location 3	Location 4	Location 5
Organic matter, %	39.5	12.4	25.1	22.4	2.3
Cd, ppm	0.00	0.00	0.00	0.00	0.00
Cr, ppm	0.00	0.00	0.00	0.00	0.00
Cu, ppm	0.02	0.08	0.05	0.00	0.00
Ni, ppm	0.00	0.00	0.00	0.00	0.00
Pb, ppm	0.00	0.40	0.23	0.22	0.23
Zn, ppm	0.16	0.12	0.22	0.14	0.08
Mg, ppm	8.05	9.27	11.69	1.90	0.85
K, ppm	5.61	8.03	7.32	4.75	2.13

organic matter in Location 1 because the location is downstream of the lake where all water from the lake will accumulate in Location 1 before channel out into Pergau river. High pH value was observed in all sampling locations especially Location 10. [Zwieg et al. \(1999\)](#) and [Fawaz et al. \(2013\)](#) reported that pH value ranging from 6.5 to 9.0 is suitable to support aquatic organisms. The sediment of Pergau Lake is comprise of sand where may lead to high value of pH.

Hierarchical cluster analysis was successfully generated a dendrogram. Based on the dendrogram, the sampling sites can be

divided into two main clusters where Location 1 alone on its own cluster. This shows that Location 1 has huge different water parameters value compared to other locations in the present study. The present study showed Location 1 possesses the highest of COD whereas Location 3 has the highest BOD. Location 1 is the downstream of Pergau Lake where all water from the lake will flush to Location 1 before discharge to Pergau river. Furthermore, Location 1 was developed as tourist spot where hotel and chalet was built in the area that may contribute to high COD value in the area. High

Table 6
Asian clam stages and density of 5 locations at Pergau Lake, Kelantan, Malaysia.

	Location 1	Location 2	Location 3	Location 4	Location 5
Asian clam density piece / m ²	50.46	113.63	-	15.29	2.21
Survival %	99.17	87.95	-	100	24.19
Maturity % Size: 14 – 16 mm	0	0	-	28.6	0
Semi Maturity % Size: 11 – 13 mm	66.7	66.7	-	57.1	100
Juvenile % Size: 8 – 10 mm	25	25	-	14.3	0
Young % Size: 5 – 7 mm	8.3	8.3	-	0	0

Asian clam sampling cannot be done in Location 6 – 10 due to safety concern.

Table 7
Pearson correlation of water quality, density, survival and stages of Asian clam, *Corbicula fluminea*.

	pH	DO	TDS	BOD	°C	COD	CR	PB	ZN	MG	K	Density	Survival	Maturity	Semi	Juv	Young
pH	1																
DO	-0.592	1															
TSS	-0.191	-0.181	1														
BOD	-0.717	0.832	0.364	1													
°C	-0.972**	0.707	0.211	0.844	1												
COD	0.009	-0.566	0.804	-0.148	-0.121	1											
Cr	-0.333	0.066	-0.296	0.079	0.369	-0.479	1										
Pb	-0.051	-0.225	0.984**	0.318	0.099	0.753	-0.288	1									
Zn	0.948*	-0.677	-0.383	-0.887*	-0.978**	-0.041	-0.206	-0.271	1								
Mg	0.581	0.041	-0.762	-0.346	-0.478	-0.799	0.292	-0.635	0.607	1							
K	0.230	0.396	-0.669	0.072	-0.073	-0.936*	0.475	-0.563	0.211	0.901*	1						
Density	-0.432	-0.058	0.130	0.195	0.461	-0.106	0.906*	0.124	-0.367	-0.060	0.152	1					
Survival	-0.529	-0.362	0.512	0.016	0.397	0.627	0.307	0.406	-0.417	-0.746	-0.691	0.590	1				
Maturity	-0.417	-0.053	-0.099	-0.167	0.206	0.338	-0.250	-0.257	-0.206	-0.543	-0.632	-0.246	0.450	1			
Semi-maturity	0.561	-0.979**	0.073	-0.838	-0.665	0.426	0.132	0.124	0.673	0.072	-0.254	0.215	0.371	-0.015	1		
Juvenile	-0.581	-0.171	0.566	0.274	0.546	0.417	0.542	0.503	-0.550	-0.594	-0.404	0.831	0.897*	0.064	0.228	1	
Young	-0.337	-0.132	0.564	0.329	0.403	0.224	0.612	0.580	-0.407	-0.290	-0.074	0.875	0.610	-0.408	0.216	0.885* 1	

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

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

Table 8
Pearson correlation of soil parameter, density, survival and stages of Asian clam, *Corbicula fluminea*.

	Density	Survival	Maturity	Semi	Juv	Young	OM	SCU	SPB	SZN	SMG	SK
Density	1											
Survival	0.590	1										
Maturity	-0.246	0.450	1									
Semi maturity	0.215	0.371	-0.015	1								
Juvenile	0.831	0.897*	0.064	0.228	1							
Young	0.875	0.610	-0.408	0.216	0.885*	1						
OM	0.015	0.362	0.080	-0.470	0.434	0.360	1					
SCu	0.704	-0.049	-0.484	-0.406	0.329	0.527	-0.005	1				
SPb	0.372	-0.169	0.016	-0.024	-0.104	-0.103	-0.725	0.563	1			
SZn	-0.215	-0.255	-0.043	-0.952*	-0.099	-0.071	0.699	0.307	-0.262	1		
SMg	0.372	-0.173	-0.525	-0.720	0.218	0.444	0.475	0.813	0.056	0.746	1	
SK	0.590	0.128	-0.197	-0.661	0.437	0.492	0.386	0.886*	0.315	0.619	0.888*	1

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

BOD value in Location 3 is due to agricultural activities such as cattle and cash crop farming in the nearby area that carried out by community. The agricultural wastes from nearby area of Location 3 lead to high BOD. In additional, water from Location 3 is cloudy compared to other sampling sites. The presence of heavy metals in the Pergau Lake may be due to agricultural wastes via fertilizer that seeping into water system (Lee and Wendy, 2011). At the meantime, tourism that involved with application of boat may also contribute to heavy metals in the lake. However, the concentration of these heavy metals is still under control.

The study of Asian clam distribution in Pergau Lake revealed that Location 1 and 2 is suitable for seasonal Asian clam harvesting activity due to high density of the clam was found. However, majority of the sampled clam was semi mature in which not yet suitable to harvest yet. This finding is indicating that over harvesting of Asian clam in the previous time. Hence, we suggest that seasonal Asian clam harvesting is the best way to maintain the clam population in the lake and permit basic in harvesting Asian clam should be implemented in order to only allow educated collector to carry out the activity.

5. Conclusion

Based on the analysis of the findings of the present study, there is no correlation or between the distribution of Asian clam and water quality of Pergau Lake. This meaning that water quality has no impact to the Asian clam distribution in the lake. It is interesting to note that the majority population of Asian clam in the lake was semi mature. This may due to excessive exploitation of Asian clam previously before Pergau Lake was gazette as State Park. Hence, we suggest that seasonal Asian clam harvesting can be carried out where can benefit both community and to conserve the population of Asian clam in the lake.

CRedit authorship contribution statement

Aweng Eh Rak: Writing – original draft, Methodology. **Zulhisyam Abdul Kari:** Supervision, Validation, Writing – review & editing. **Mohd Zharif Ramli:** Software, Validation. **Hasnita Che Harun:** Software, Validation. **Suniza Anis Mohamad Sukri:** Software, Validation. **Hazreen Nita Mohd Khalid:** Software, Validation. **Faizuan Abdullah:** Software, Validation. **Mahmoud A.O. Dawood:** Supervision, Validation, Writing – review & editing. **Wendy Wee:** Software, Validation. **Lee Seong Wei:** Funding acquisition, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This project was funded by Minister of Education Malaysia under Transdisciplinary Research Grant Scheme (TRGS) vot no: R/TRGS/A0.700/00387A/007/2016/000391 and UMK-Prototype Grant (R/PRO/A0800/00244A/006/2020/00867).

References

- Astel, A., Biziuk, M., Przyjazny, A., Namieśnik, J., 2006. Chemometrics in monitoring spatial and temporal variations in drinking water quality. *Water Res.* 40 (8), 1706–1716.
- Beaver, J.R., Crisman, T.L., Brock, R.J., 1991. Grazing effects of an exotic bivalve (*Corbicula fluminea*) on hypereutrophic lake water. *Lake and Reserv Manage* 7 (1), 45–51.
- Chen, H., Zha, J., Liang, X., Bu, J., Wang, M., 2013. Sequencing and De Novo assembly of the Asian Clam (*Corbicula fluminea*) transcriptome using the illumina GAlIx Method. *PLoS ONE* 8, (11) e79516.
- Fawaz AB, Suhaimi – Othman M, Muhd BG. 2013. Water quality assessment of the Semenyih River, Selangor, Malaysia. *J Chemistry ID* 871056.
- Gadhia, M., Surana, R., Ansari, E., 2012. Seasonal variations in physico-chemical characteristics of Tapi estuary in Hazira industrial area. *Our nature* 10, 249–257.
- Hach. (2005). Procedures manual, DR5000 spectrophotometer.
- HACH, 2007. Dr 2800 Spectrophotometer Procedure Manual. HACH, Germany.
- Klein, R.L., Gibbs, C., 1979. Standard Methods for the Examination of Water and Wastewater Journal of Water Pollution Control Federation. 51 (9), 2257.
- Lee, S.W., Wendy, W., 2011. Antibigram and heavy metal resistance pattern of *Salmonella* spp. isolated from wild Asian sea bass (*Lates calcarifer*) from Tok Bali, Kelantan, Malaysia. *Jordan. J. Biol. Sci.* 4 (3), 125–128.
- Lee, S.W., Wendy, W., Zalina, C.M., Ruhul, M.A., Sukree, H., 2013. A study of *Edwardsiella tarda* colonizing live Asian clam, *Corbicula fluminea*, from Pasir Mas, Kelantan, Malaysia with emphasis on its antibiogram, heavy metal tolerance and genetic diversity. *Vet. Archiv.* 83 (3), 323–331.
- Novais, A., Batista, D., Cassio, F., Pascoal, C., Sousa, R., 2017. Effects of invasive clam (*Corbicula fluminea*) die-offs on the structure and functioning of freshwater ecosystems. *Freshw. Biol.* 62 (11), 1908–1916.
- Ramli, M.Z., Ibrahim, A., Yusoff, A., Rak, A.E., Lee, S.W., 2021. Effects of feeding treatments on growth and survival of Asian clam (*Corbicula fluminea*) in the hatchery. *J. Agrobiotechnol.* 12 (1), 58–65.
- Ravindra K, Ameena M, Monika R, Kaushik A. Seasonal variations in physiochemical characteristics of river Yamuna in Haryana and its ecological best designated use. *J. Environ. Monit.* 5: 419–426.
- Sharma, R.K., Rathore, V., 2000. Pollution ecology with reference to commercially important fisheries prospect in rural-based water body: the Lake Sarsai Nawar, Etawah (Uttar Pradesh). *Pollut. Res.* 19, 641–644.
- Saiful Islam, M., Uddin, M.K., Tareq, S.M., Shammii, M., Kamal, A.K.I., Sugano, T., Kurasaki, M., Saito, T., Tanakan, S., Kuramitz, H., 2015. Alteration of water pollution level with the seasonal changes in mean daily discharge in three main rivers around Dhaka City, Bangladesh. *Environments* 2, 280–294.
- Suhaimi-Othman, M., Lim, E.C., Mushrifah, I., 2007. Water quality changes in Chini Lake, Pahang West Malaysia. *Environ. Monitoring Assessment* 131 (1–3), 279–292.
- Sriyasak, P., Chitmanat, C., Whangchai, N., Promya, J., Lebel, L., 2015. Effect of water de-stratification on dissolved oxygen and ammonia in tilapia ponds in Northern Thailand. *Int. Aqua Res.* 7 (4), 287–299.
- Zwieg, R.D., Morton, J.D., Stewart, M.M., 1999. Source water quality for aquaculture: A guide for Assessment. The World Bank, Washington D.C..
- Zulhisyam, A.K., Kabir, M.A., Dawood, M.A., Razab, M.K.A.A., Ariff, N.S.N.A., Sarkar, T., Pati, S., Edinur, H.A., Mat, K., Ismail, T.A., 2022. Effect of fish meal substitution with fermented soy pulp on growth performance, digestive enzyme, amino acid profile, and immune-related gene expression of African catfish (*Clarias gariepinus*). *Aquaculture* 737418.