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Assessment of Physicochemical Properties of Water and Public Perceptions of Water Quality in Tasik Chini, Pahang, Malaysia

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ABSTRACT

The study was conducted to evaluate the physicochemical parameters of water and assess the public perception of the water quality status in the Tasik Chini watershed based on a community survey. The water sample was analyzed based on standard methods and categorized according to WQI (Water Quality Index). Multivariate statistical analysis was adopted to find spatial variations in water quality, determining the pollution level and sources of contamination. The study results were compared with NWQS (National Water Quality Standard for Malaysia). The results showed that the value of dissolved oxygen (DO) was low (4.68 $mg.L^{-1}$), while the level of biological oxygen demand (BOD), chemical oxygen demand (COD), and total dissolved solids (TDS) was found to be high, 2.92 $mg.L^{-1}$, 26.10 $mg.L^{-1}$ and 22.93 $mg.L^{-1}$ respectively. High turbidity was recorded in a mining area in the rainy season (35.76 NTU). The DOE-WQI value categorized the lake under class II and class III. The Principal Component Analysis (PCA) revealed that the major sources of contamination were due to anthropogenic activities, especially settlement, mining, agriculture, and illegal activities. Overall, Tasik Chini's water quality status was classified as slightly polluted to highly polluted based on hierarchical cluster analysis (CA) results. The survey showed that 55% of the local community reported that the water quality was poor. The knowledge and attitude level of the local people was medium category, while community practice was low. The Pearson correlation coefficient test showed a strong significant relationship at 0.01 level between knowledge and attitude and knowledge and practices. The scientific findings with public perceptions might be useful for policymakers and the general public to improve the management system for a desirable future.

INTRODUCTION

Water resources an important for human beings as well as for industrial and agricultural purposes. One of the most important concerns of the twenty-first century is to ensure that everyone has access to safe and secure drinking water. However, the water demand is always increasing across the globe, and the quality of the world's water resources is worsening as a result of human activities (Phong et al. 2023). Various industries, wastewater treatment facilities, mining sites, excessive use of fertilizers and pesticides in agriculture, and other anthropogenic activities produce effluents containing physical and chemical contaminants, among other things. The degradation of water quality as a result of these toxins may lead to certain major environmental issues, posing a hazard to aquatic communities' general health (Islam et al. 2022). The quality of the surface water system changes based on multiple factors from natural variations and anthropogenic activities. The anthropogenic processes such as industrial untreated effluents, domestic waste, and agricultural discharge are the prime contributors to surface water pollution and water quality deterioration (Madilonga et al. 2021). The direct release of improperly disposed domestic waste, industrial wastewater, and agricultural runoff in watersheds leads to an increase in freshwater pollution and depletion of clean water resources (Sujaul et al. 2015). As a result, public awareness of the relevance of surface water quality to human health and the environment has grown, and numerous researches have been focused on assessing surface water quality and mitigating its environmental contamination impacts (Caputo et al. 2022).

Public awareness about surface water quality plays an important role in successful pollution prevention. Local communities that live close to nature have significant and long-standing relationships with it. However, they build up an intimate and intuitive understanding of the environment over long periods. Local perceptions of natural resources are derived from daily interactions with the environment. Therefore, the experiences and knowledge of local people can help to reduce the pollution load into surface water. Perception research plays a very important part in global change and sustainable development (Mahler 2021, Khalid et al. 2018). Public perception of environmental issues has been of interest to many researchers and policymakers for several years. These have been obtained through a range of different methods, primarily quantitative social surveys and, more recently, in-depth qualitative studies. Several studies have argued that people's perceptions and attitudes toward the depletion of natural resources are influential to the wise use and management of natural resources (Caputo et al. 2022, Akter et al. 2017).

In this situation, an attempt was made to look into the current status of water quality using water quality standards. Pearson regression and correlation, principal component analysis (PCA), and cluster analysis (CA) have all been frequently done for the assessment and evaluation of lake water quality. Keeping the view in consideration, a social survey (very similar to the KAP survey) was conducted to evaluate the knowledge, perception, and awareness of the local communities on changes in water quality in the Tasik Chini watershed. The study was done to generate quantitative information about the water quality using scientific findings and communities' knowledge and perceptions. Therefore, the purpose of this study is to assess the characteristics of physicochemical parameters and sources of pollutants and to determine public awareness regarding the water quality in Tasik Chini.

MATERIALS AND METHODS

Study Area

Tasik means Lake in Malay. Tasik Chini (Chini Lake) is the second-largest natural freshwater lake in Malaysia. The lake system lies between 3°22´30" to 3°28´00" N and 102°52´40" to 102°58´10" E. The Chini is located in the southeastern region of the state of Pahang (Ali & Lee 1995) and around 100 kilometers away from Kuantan, the capital city. Tasik Chini covers 202 hectares of open water and 700 ha of Riparian, Peat, Mountain, and Lowland Dipterocarp forests (Fig. 1). Three hills, namely Bt. Ketaya (209 m), Bt. Tebakang (210 m), and Bt. Chini (210 m) surrounds the gazetted Tasik Chini Park and its watershed (641 m). Only Butit Chini has certain endemic environments (Marimuthu & Zakariah 2020). In this tropical, hot, and humid environment, annual rainfall ranges from 1,488 to 3,071 mm. Twelve different reservoirs create a finger-like structure known as "Laut" locally. Indigenous dipterocarp forest is heavily inhabited in the riparian zones and neighboring lowlands. There are only two seasons in the studied region: dry season and wet season (Islam et al. 2012).

Water Sampling

Water quality varies depending on geographic location, weather, human activities, and site-specific conditions. While point sources of pollution, such as domestic or industrial discharge, are relatively easy to identify and control, non-point sources of pollution, such as urban or agricultural

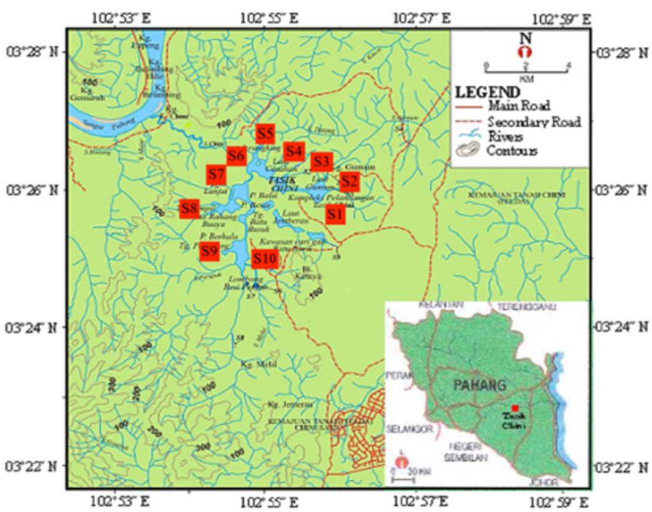

Fig. 1: Location of the study area and sampling stations.

Table 1: Description of the sampling station and surrounding area.

Stations	Grid References	Location	Source of pollution
S1	03º25′331″ 102º55′662″	Laut Jemberau, near to the Jemberau River	Mining and forest area
S2	03º25′413″ 102º55′385″	Laut Batu Busuk	National service training camp, primary forest and logging area
S3	03º24′877″ 102º54′727″	Laut Melai, near the Melai River	Logging, agricultural, and mining area
S4	03º24′970″ 102º54′642″	Laut Serodong	Agricultural and mining area
S5	03º25′940″ 102º54′653″	Laut Kenawar	Forest and rubber plantation area
S6	03º26′283″ 102º54′726″	Laut Gt. Teratai	Rubber plantation and upland primary forest area
S7	03º26′512″ 102º54′773″	Draining point of the lake at the initiation of the Chini River	Draining end point of Tasik Chini at Chini River
S8	03º26′248″ 102º55′89″	Laut Cenahan, near the jetty	Cenahan Village and agricultural area
S9	03º25′986″ 102º55′334″	Laut Pulau Balai, near the tourist main jetty	Tourist settlement zone, secondary forest, and rubber plantation area
S10	03º26′131″ 102º55′707″	Laut Gumum, near the jetty	Gumum village, agriculture, shifting cultivation, and oil palm plantation area

sources, are more difficult to identify and control (Haldar et al. 2020). The monitoring stations were chosen based on the probable sources of pollution (Fig. 1), which included urban, agricultural discharges, settlement, and forest areas. Water samples were taken from 10 chosen sites and 10-15 cm below the surface using 1000 mL HDPE bottles. According to (Baird 2017), water sampling for BOD analysis was obtained using dark BOD vials (300 mL) bottles. For subsequent examination, the collected samples were kept in the laboratory cold room in a cool and dry environment below 4°C. Fig. 1 shows the locations of both types of water samples in the study area. The latitude and longitude coordinates and the surrounding area of the monitoring stations are shown in Table 1.

Water Quality Assessment

Temperature, pH, turbidity, DO, EC (electrical conductivity), and salinity were monitored in situ using a portable YSI multisensory instrument (model 6600-M). A spectrophotometer was used to measure ammoniacal nitrogen (AN), Phosphate (PO_4), Sulfate (SO_4), Nitrate (NO_3), and COD (HACH DR5000 model and HACH 2010). TSS and TDS were measured in the laboratory using the Gravimetric technique, whereas BOD was determined using a DO meter.

The assessment of the water quality of the Tasik Chini Lake was done using the Water Quality Index (WQI). Six parameters were obtained to calculate WQI (DOE 2014). The following equation (1), developed by the Department of Environment; in Malaysia, based on six water quality parameters (Naubi et al. 2016), was used to calculate DOE-WQI. WQI is the sum of weighted subindices for six variables (DO, BOD, COD, NH_3-N, TSS, and pH). The subindices values are derived based on segmented nonlinear functions. The value of the weighted subindices is a score between 0 and 100 that is categorized into five classes (I - V) to suggest the uses of water. The equation (1) is illustrated below:

$$WQI=0.22\times SIDO+0.19\times SIBOD+0.16\times SICOD+0.15\times SIAN+0.16\times SITSS+0.12\times SIPH \quad \ldots(1)$$

Where the SI indicates the sub-index function and the coefficients are the weights for the corresponding parameters with a total value of unity.

Questionnaire Survey

A well-structured, closed-ended questionnaire was designed to better understand the local people's knowledge, perception, environmental awareness, and attitudes to water quality. The questionnaire consisted of 36 closed-ended questions and was designed with four categories covering respondents' demographic information, knowledge and perception of water quality, source of information, as well as awareness and willingness to participate as a volunteer in a watershed management program. To make the survey easier for responders, the questionnaires consisted of six parts. The first part was designed to obtain general information on age, gender, race, educational qualification, occupation, family members, and place of residence. The second part contained

4 different types of questions, which are related to the water quality of the Tasik Chini area. The third, fourth, and fifth parts are related to local people's knowledge, attitudes, and practice of local people to pollution issues and management. The last part was done to know the portability of the local community to participate in a collaborative project with authorities for the management of the study area. The questionnaire surveys were conducted in the watershed area using Equation (2) to get the demographic information of the respondents, knowledge about water quality and sources of pollutants. The questionnaire surveys were conducted using the following Equation 2 (Ahmed et al. 2018).

$$n = N/1+N(e)^2 \quad ...(2)$$

Where, n = sample size; N = population size; e = level of perception, 0.05 at 95%

Statistical Analysis

A descriptive statistical analysis was performed to show the range (minimum-maximum), mean value, and standard deviation for the physicochemical variables in water samples. For social survey data, a descriptive analysis of respondents' demographic characteristics was conducted. The frequencies procedure was applied to summarize the measures of demographic information and presented under the study. The analysis was also performed for communities' knowledge and perceptions of water quality (Nagaraju et al. 2016, Tanjung et al. 2020). The relationship among the physicochemical parameters was measured using Pearson correlation (two-taildel) analysis. The regression and correlation were calculated using IBM SPSS software (version 22) to determine significant differences among the physicochemical water quality parameters. The Principal Component Analysis was used to identify potential pollution sources, while the Cluster Analysis was used to organize the monitoring stations by contamination level (Arafat et al. 2017).

Non-Parametric Test

Before statistical analysis, water quality parameters were examined for normality of distribution using the Shapiro-Wilk's test (p> 0.05) (Razali & Wah 2010). All the parameters showed a violation of the normal distribution and equal variance assumptions of the parametric tests. Hence, a nonparametric test was performed to compare significance differences. Non-parametric tests were carried out in the statistical analyses due to non-normal distributions of the parameters. A non-parametric Lavene's test was used to verify the equality of variances (p> 0.05) (Martin & Bridgmon 2012). The nonparametric Kruskal-Wallis test was performed to estimate the significant differences in water quality parameters under different sampling stations and seasons (p-value < 0.05) (Ling et al. 2017).

RESULTS AND DISCUSSION

Physicochemical Assessment of Water

Table 2 shows the water quality and standard deviation of parameters at different sampling stations. The average temperature measured along the Tasik Chini was 29.88±2.01°C, which ranged from 26.70°C to 32.05°C. The highest temperature value was recorded in July (32.05°C) at station S5, while the lowest in December (26.70°C) at station S10. The temperature readings showed little regional variation but did exhibit temporal variation. Moreover, most of the stations showed higher temperatures in the dry season than in the rainy season. The average temperature in the study area was found to be within the threshold level of the Malaysian standard. The highest turbidity was recorded at station S1 during the rainy season (35.76 NTU), while the lowest was recorded at station S10 during the dry season (17.20 NTU). Turbidity showed a positive relationship (Table 3) with SO_4 (r=0.295, P<0.01), according to a correlation study. The average value of turbidity at all stations was classified as class II based on NWQS, Malaysia (EQR 2016). The mean concentration of TSS was 9.11± 3.42 mg.L^{-1}; the highest value was recorded at station S6 (18.70 mg.L^{-1}) during the wet season (December) and the lowest at station S10 (4.08 mg.L^{-1}) during the dry period (July). The mean total dissolved solid in Tasik Chini was 22.93±1.96 mg.L^{-1}, ranging from 15.66 to 34.66 mg.L^{-1}. The lowest TDS value was found to be at Station S8 (10.20 mg.L^{-1}), whereas the highest concentration was recorded at Station S3. The values of TDS were found to be higher than expected in the mining zone due to illicit deforestation. TDS value has only a positive relationship with electrical conductivity EC (r=0.535, P<0.01), according to correlation analysis. The TDS levels increased in general when the season changed from dry to rainy.

The average value of pH measured along the Tasik Chini was 6.26. Station S10 reported the highest pH value (7.91), while station S1 recorded the lowest (5.65). The majority of the stations were found to be mildly acidic. In natural waterways, a low pH value implies the presence of a lot of organic matter (Matilainen et al. 2011). The salinity results ranged from 0.00 to 3.00%. The highest concentration of salinity (2.80%) was observed at station S7 in April, and the lowest was recorded at station S4 (0.03%) in December. An average of 31.46 μS.cm^{-1} electrical conductivity was recorded in the lake during the study period. The concentration of DO value varied from 4.83 to 6.11 mg.L^{-1}, with a mean of 5.19 0.41± mg.L^{-1}. The DO value in Chini Lake water was shown to be positively correlated with temperature (r=0.435, P<0.01). The DO value near the settlement area was recorded as low. Most of the stations along the water body were acidic due to a shortage of DO. The average value of BOD in Chini Lake was 2.92±0.52 $mg.L^{-1}$; it ranged from 2.58 to 3.07 $mg.L^{-1}$. BOD value was positively correlated with DO (r=0.200, P<0.01), pH (r=0.404, P<0.01), SO_4 (r=0.173, p>0.01) and negatively correlated with EC (r=-0.232, P<0.01) and TDS (r=-0.362, P<0.01). The mean COD value was 26.10±4.50 $mg.L^{-1}$, ranging from 17.23 to 32.24 $mg.L^{-1}$. The COD value was positively correlated with DO (r= 0.213, P<0.01) and AN (r=0.263, P<0.01) and negatively correlated with pH (r=-0.219, P<0.01). The maximum value (42.24 $mg.L^{-1}$) of COD was recorded at station S3 in June, and the lowest value (14.23 $mg.L^{-1}$) was recorded at station S10 in August. The threshold level of COD for surface water in Malaysia (NWQS) is 60.00 $mg.L^{-1}$ (EQR 2016).

The average ammoniacal nitrogen (NH_3-N) (AN) content in Tasik Chini was 0.66±0.22 $mg.L^{-1}$, which ranged from 0.14 to 1.31 $mg.L^{-1}$. All samples collected during dry and wet seasons were lower than the threshold level of the Malaysian standard (EQR 2016). The value of NH_3-N showed a positive correlation with COD (r=0.263, P<0.01) and a negative with pH (r=-0.294, P<0.01). The average NO_3 value in Tasik Chini was 0.38 $mg.L^{-1}$, ranging from 0.12 to 0.80 $mg.L^{-1}$. NO_3 showed a positive relationship with turbidity (r= 0.159, p>0.05) and BOD (r=0.154, p=0.05). The PO_4 levels of water samples measured across the seasons varied from 0.08 to 019 $mg.L^{-1}$. The average concentration was recorded at 0.13 $mg.L^{-1}$. The highest value (0.19 $mg.L^{-1}$) was recorded at station S3 during the wet season, and the lowest (0.08 $mg.L^{-1}$) was recorded at station S10 during the dry season. The PO_4 value was positively correlated with ammoniacal nitrogen (r=0.398, P<0.01). The SO_4 content in water samples ranged from 0.32 to 2.00 $mg.L^{-1}$, on average of 0.79±0.04 $mg.L^{-1}$. The highest SO_4 concentrations were recorded at station S4 (2.00±0.17 $mg.L^{-1}$) and the lowest at station S5 (0.32 $mg.L^{-1}$). All the samples collected during the dry and wet seasons were far below the maximum permissible limit (250.00 $mg.L^{-1}$) set by NWQS, Malaysia (EQR 2016).

Water Quality Index

The water quality index value of different stations in Tasik Chini water body was calculated based on six parameters, namely DO, BOD, COD, TSS, NH_3-N, and pH, and their sub-index value. The calculated WQI values for the 10 stations varied from 51 to 86 (Table 4). Based on the WQI score, stations S1, S2, S5, S6, S7, S8, S9, and S10 were classified

Table 2: Water quality parameters of the Tasik Chini at different stations.

Station	Temp	EC	TDS	DO	PH	Turbidity	BOD	COD	TSS	Salinity	AN	PO_4	SO_4	NO_3
	°C	$\mu S.cm^{-1}$	$mg.L^{-1}$	$mg.L^{-1}$		NTU	$mg.L^{-1}$	$mg.L^{-1}$	$mg.L^{-1}$	%	$mg.L^{-1}$	$mg.L^{-1}$	$mg.L^{-1}$	$mg.L^{-1}$
S1	30.06	30.31	23.33	5.83	5.74	35.76	2.24	26.75	7.17	0.04	0.14	0.18	1.06	0.20
	±0.60	±1.45	±0.56	±0.12	±0.06	±1.10	±0.04	±0.21	±0.30	±0.01	±0.05	±0.03	±0.24	±0.11
S2	30.81	29.65	22.00	5.86	6.17	16.06	2.70	27.18	11.10	0.23	0.19	0.12	0.33	0.26
	±0.30	±2.09	±1.53	±0.08	±0.02	±3.09	±0.04	±018	±0.15	±0.20	±0.03	±0.03	±0.21	±0.13
S3	30.62	31.68	27.33	4.96	6.41	22.88	3.07	29.15	7.08	0.026	0.28	0.21	0.66	0.29
	±0.51	±0.58	±0.34	±0.05	±0.01	±2.15	±0.01	±0.09	±0.32	±0.01	±0.02	±0.01	±0.31	±0.14
S4	30.50	31.31	21.33	4.68	6.39	27.33	2.80	22.33	11.10	0.03	0.54	0.19	2.00	0.14
	0.75±	±0.54	±1.67	±0.04	±0.01	±0.95	±0.04	±0.25	±0.27	±0.01	±0.01	±0.02	±0.19	±0.08
S5	31.90	30.66	17.33	5.77	6.31	13.14	2.57	23.14	9.60	0.14	0.47	0.09	0.32	0.20
	±0.45	±1.67	±2.58	±0.09	±0.03	±3.90	±0.04	±0.20	±0.25	±0.20	±0.01	±0.04	±0.16	±0.09
S6	31.47	30.32	18.33	5.62	6.27	16.10	2.21	20.2	18.70	0.05	0.64	0.16	0.90	0.25
	±0.60	±1.87	±2.52	±0.04	±0.02	±2.25	±0.05	±0.35	±0.08	±0.01	±0.01	±0.01	±0.35	±0.10
S7	32.02	30.65	18.33	4.99	6.41	25.84	2.61	24.09	11.04	2.80	0.74	0.11	0.42	0.12
	±0.35	±1.65	±2.26	±0.11	±0.01	±1.15	±0.03	±0.15	±0.21	±0.07	±0.01	±0.01	±0.28	±0.04
S8	31.72	28.67	18.00	4.90	6.19	34.20	2.41	20.16	9.94	0.04	1.31	0.09	0.66	0.14
	±0.26	±3.06	±1.98	±0.11	±0.03	±0.25	±0.02	±0.30	±0.26	±0.01	±0.01	±0.01	±0.32	±0.05
S9	31.36	32.62	18.67	6.08	6.32	26.81	2.33	24.73	9.16	0.09	0.90	0.13	0.61	0.41
	±0.55	±1.05	±1.67	±0.02	±0.04	±0.85	±0.04	±0.09	±0.20	±0.02	±0.01	±0.02	±0.25	±0.08
S10	29.75	34.68	19.33	5.79	6.24	17.20	2.33	18.53	4.08	2.60	0.49	0.08	0.83	0.80
	±0.45	±0.35	±1.12	±0.01	±0.01	±2.10	±0.05	±01.11	±1.25	±0.19	±0.01	±0.03	±0.37	0.13±

Table 3: Pearson correlation coefficient among the parameters of water quality at Tasik Chini.

	Temp	EC	TDS	DO	PH	Turbidity	BOD	COD	TSS	Salinity	AN	PO_4	$S0_4$	NO_3
Temp	1													
EC	-0.271**	1												
TDS	-0.366**	0.535**	1											
DO	0.435**	-0.210**	-0.161*	1										
PH	0.285**	-0.079	-0.178*	0.196**	1									
Turbidity	0.044	-0.073	-0.043	-0.008	0.052	1								
BOD	0.407**	-0.232**	-0.362**	0.200**	0.404**	0.050	1							
COD	0.161*	0.184*	-0.044	0.213**	-0.219**	-0.037	-0.003	1						
TSS	0.012	0.069	-0.262**	-0.382**	0.183*	-0.021	0.006	-0.076	1					
Salinity	-0.108	-0.086	0.075	-0.084	0.033	0.193**	-0.023	-0.128	-0.083	1				
AN	0.105	0.064	0.045	0.143	-0.294**	0.001	-0.078	0.263**	-0.127	-0.095	1			
PO_4	0.092	-0.019	-0.052	0.098	0.101	-0.103	0.002	0.106	-0.042	-0.040	0.398**	1		
SO_4	0.073	-0.075	-0.147*	-0.043	-0.104	0.295**	0.173**	0.039	0.044	-0.119	0.219**	0.051	1	
NO_3	0.053	0.031	-0.077	-0.031	-0.003	0.159*	0.154*	-0.027	0.048	-0.004	-0.108	-0.067	-0.046	1

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

as Class II (slightly polluted), whereas stations S3 and S4 were classified as Class III (polluted). The WQI scores for stations S3 and S4 were the lowest among the stations. The calculated DO value at the two stations (S3 and S4) was the lowest due to the flooding area. The results showed that the concentration of organic matter and nutrients, particularly phosphate, affected the water quality status of Stations S3 and S4. These stations are close to an indigenous peoples' community in the Gumum region, an agricultural area, as well as a resort and a National Service Centre camp, all of which might contribute to organic loading. Improper treatment of sanitation in local communities, resorts, and camps areas may introduce additional biological loadings into the lake, raising BOD levels. On the other hand, the lake surrounding the forest area was almost clean. In the study area, the water quality index value agreed with the study conducted by Sujaul et al. (2013).

Table 4: Water quality classification based on DOE-WQI.

Sampling Stations	WQI	CLASS	WQ STATUS
S1	84	II	SP
S2	83	II	SP
S3	51	III	P
S4	53	III	P
S5	83	II	SP
S6	86	II	SP
S7	83	II	SP
S8	84	II	SP
S9	83	II	SL
S10	83	II	SP

P = Poluted and SP = Slightly Polluted, Class I = >92.7, Class II = 76.5 – 92.7, Class III = 51.9 – 76.5, Class IV = < 51.9

However, Tasik Chini water quality was classified as class II overall. WQI fluctuates depending on the location of stations in the lake. Table 4 demonstrates the WQI values and status during the study period. According to DOE-WQI, the water quality in the study area is sensitive to aquatic species and only suitable for recreational use with body contract (DOE 2014).

Water Quality Based on Principal Component Analysis

PCA is a multivariate analysis technique that has been used to discover new variables characterized by a linear combination of variables with correlations via the variance-covariance matrix of several multivariate variables; it clarifies the majority of the total variations with some important principal components (Jung et al. 2016). PCA may classify contaminants into multiple categories based on their loading, with the highest loading component describing the whole data set's characteristics (Ebrahimi et al. 2017). Five principal components were extracted from PCA. The PC1 explained 20.64% of the total variation, which was strongly loaded on electrical conductivity (0.903) and TDS being heavily loaded (0.905). The second PC2, which comprises three parameters: DO (0.433), NH_3-N (AN) (0.403), and SO_4 (0.738), explained 11.46% of total variability, whereas the other three PC3, PC4, and PC5 explained 10.64%, 8.28%, and 7.78% of total variability, respectively (Table 5). PC1 was significantly loaded (>0.75), according to the

Table 5: Rotated component matrix for physicochemical parameters in water.

	PC1	PC2	PC3	PC4	PC5
TEMP	0.129	-0.243	0.115	0.555	-0.269
PH	0.025	-0.152	-0.091	0.143	0.174
DO	-0.059	0.433	0.350	0.120	0.357
EC	0.903	0.141	0.226	-0.132	-0.036
TDS	0.905	0.092	0.183	-0.087	-0.093
TUR	-0.532	0.215	0.643	0.169	0.122
TSS	-0.293	-0.556	0.418	0.225	-0.214
BOD	-0.616	0.278	0.099	-0.213	-0.151
COD	0.497	-0.166	0.143	0.559	0.120
NH_{3-N}	-0.131	0.403	-0.247	0.196	-0.519
Salinity	-0.380	-0.370	0.162	-0.011	0.292
PO_4	0.102	0.043	-0.346	0.135	0.629
SO_4	-0.046	0.738	0.119	0.376	0.036
NO_3	0.251	-0.014	0.649	-0.395	-0.010
Eigenvalues	2.889	1.605	1.489	1.159	1.089
% of variance	20.635%	11.464%	10.635%	8.276%	7.781%

factor loading categorization by Low et al. (2016). PC2 and PC3 were characterized as moderated loading. In PC4, the COD was described as somewhat loaded. Finally, PC5 was also mildly loaded on PO_4. The component plot (Fig. 2) supported all classifications. The Strong loading parameters indicate similar effects that affect negatively on surface water quality and cause pollution of it. The components of the same group are originated from similar sources, and strong loading indicates significant anthropogenic activities such as agriculture, mining, logging, building, etc.

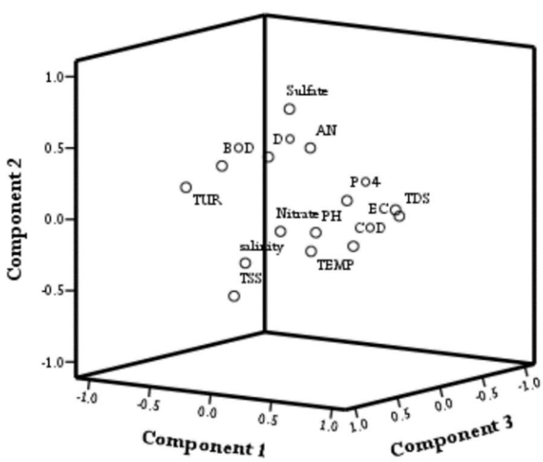

Fig. 2: Component plot in rotated shape for the physicochemical parameters of water.

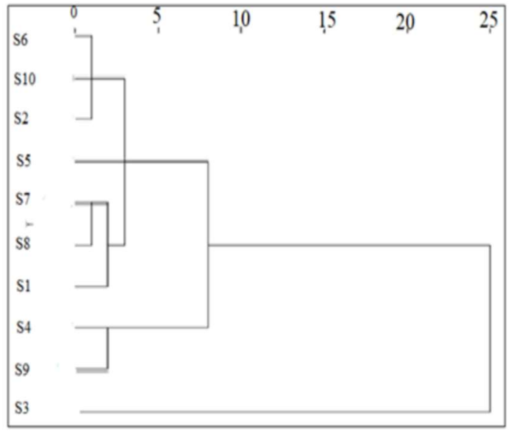

Fig. 3: Dendrogram showing different clusters of sampling sites located in the study area.

Cluster Analysis

Cluster analysis (CA) is commonly used to examine both temporal and spatial variations in water quality information (Hajigholizadeh & Melesse 2017). Hierarchical cluster analysis (HCA) was used to classify the sampling station based on pollutant similarities. This analysis was done based on the pollution status of all physicochemical parameters, where 10 stations were categorized into similar groups of pollution. Temperature, pH, EC, turbidity, salinity, DO, BOD, COD, TSS, TDS, SO_4, PO_4, AN (NH_3-H), and NO_3 were taken into consideration. The pollution level of sampling stations was categorized using cluster analysis based on their degree of similarity (Samsudin et al. 2011). Station S3 was under Cluster 1, which was highly polluted, whereas Cluster 2 (S9, S4, and S5) was assigned as a moderate pollution source (MPS). Cluster 3 (S1, S8, S7, S2, S10, and S6) was eventually designated as a low pollution source (LPS) (Fig. 3). This technology can complement future spatial sampling efforts by providing dependable clustering of water quality in any location (Juahir et al. 2010). Based on hierarchical cluster analysis results, the order of all stations is as follows: S3> S9> S4> S5> S1> S8> S7> S2> S10> S6.

Perception of Water Quality

Community perception about the water quality: There are two quantitative variables in this demographic section of the community survey for the community (Table 6). The questions were about the family members and duration of stay in the studied area (Tasik Chini Lake). The results showed that the size of the family varied from 2 to 12 members, with an average of 6 members, and this variable also had a variation of approximately 2 members. On the other hand, the average duration of permanent residence in this area was 15 years, and the stay range was

Table 6: The minimum, maximum, average, and standard deviation of family members and years of living for the local community.

	N	Minimum	Maximum	Mean	St. Deviation
How many members of your family?	100	2	12.00	6.1100	2.1022
How long have you been here?	100	2	50.00	15.020	10.1120

Table 7: The minimum, maximum, average, and standard deviation of years of work and total work experience for employees in the agricultural sector.

	N	Minimum	Maximum	Mean	St. Deviation
Your total working experience as a professional	100	2	35.00	15.1920	9.00810
How long have you been working here?	100	2	30	9.0110	6.5870

from 2 years to 50 years with a standard deviation of 10 years. The average family size and stay in the community showed that the people from the community had sufficient stakes and concerns regarding the environment because they had a moderate quantity of their families and spent enough time observing the environmental changes in the water quality.

The majority of the community (55%) reported that the quality of Tasik Chini water was poor. However, the remaining people (45%) said that it was good. The first group of local communities (24%) reported that it was difficult to use the lake water in their routine work like before. About 23% of total people agree that the water quality has been degraded, and 15% strongly agree that the quality of water has been degraded over time. However, 22% of people showed a neutral to this question. Only 19% of the people disagreed, and almost the same percentage strongly disagreed (19%) with this statement.

Agricultural respondents' perception of water quality: There are two quantitative variables in this section which are total working experience and experience with a current employer (Table 7). Results have shown that the employees have sufficient working experience, and the mean total experience was 15 years with 9 years of standard deviation. On the other hand, employees had almost 9 years of average experience with their current employer with a standard deviation of 6 years. The results indicated that the majority of agricultural representatives knew about the current employment policies and practices regarding the environment control plan because they had almost 10 years of experience with their current employer.

The majority of agricultural workers shared that the water quality of the Tasik Chini was poor. But more importantly, this percentage was 75% higher than the community people survey. It gave little idea about the knowledge difference between community and agricultural employees regarding the water quality and their true observation. 75% of the total workers collectively agreed that water has deteriorated over time. Half of them strongly agreed, and the other half just agreed with this change. 25% of participants showed a neutral attitude about water degradation. Only 5% did not agree with the water quality change over time.

Community Knowledge, Attitude, and Practice Toward Water Quality

The correlation based on the Pearson correlation coefficient for community data is given in Table 8. The range of correlation values is from -1 to +1. A correlation value of zero indicates that there is no association, but a value close to 1 indicates that there is a substantial relationship. The significance of the link is characterized by a sign of (**) in the table of correlation coefficients. Knowledge and attitude of local people have a correlation coefficient of 0.450**, which showed a positive correlation. The correlation between practices and knowledge has a strong relationship (0.540**), medium relationship is between practice and attitude (0.475**). Moreover, ** showing this relationship was highly significant means the relationship was significant at 0.01 level significance. The table highlighted that all components were positively correlated to each other with high significance. The relationships can lead to more positive practices and attitudes for managing and protecting the environment and vice versa. Knowledge systems influence community people's better attitudes and practices toward environmental management systems (Al Amin et al. 2021).

Agricultural respondents' knowledge, attitude, and practice toward water quality: The knowledge and attitude of agricultural respondents have a strong positive correlation with a value of 0.580**, showing that both components have positively correlated with each other. ** showed a high significance, which means this relationship was significant at a 0.01 level of significance (Table 9). Attitude and knowledge

Table 8: The correlation test results between knowledge, attitude, and practice aspects of community respondents.

	Knowledge	Attitude	Practices
Knowledge	1		
Attitude	0.450**	1	
Practices	0.540**	0.475**	1

**. Pearson correlation is significant at 0.01 level (2-tailed); N = 100

Table 9: The correlation test results between knowledge, attitude, and practice aspects of agricultural respondents.

	Knowledge	Attitude	Practices
Knowledge	1		
Attitude	0.580**	1	
Practices	0.920**	0.880**	1

**Pearson correlation is significant at 0.01 level (2-tailed); N = 100

also highlighted the strongest relationship (0.920). The relationship between attitude and practices also has a strong significant correlation with practices (0.880). This finding indicated that the agricultural respondents have sufficient knowledge and a positive attitude toward environmental protection plans. However, they do not practice as per the given standard practices regarding the protection of the environment. Better Knowledge, human attitudes, and practices by the local community greatly influence the conservation and management system of the watershed (Sridhar et al. 2020).

Public Authorities' Perception of Water Quality

Only eight people were working in the Department of Environment around the concerned area. They have a high level of education, experience, and sufficient knowledge about the area and the status of Tasik Chini water quality. The employees of the Department of Environment rate the quality of water in the clean category. However, the majority of local community and agricultural workers shared that the water quality of the Tasik Chini was poor. This contradiction was possible because it was the primary duty to reduce environmental degradation and maintain the balance of the environment. If they reported that water quality was not good, they would create a problem for themselves.

CONCLUSIONS

Tasik Chini is invaluable for its presence and function as a wetland and for biodiversity in the environment. Temperature, DO, BOD, and COD values were found to increase in the dry season, whereas turbidity, TSS, TDS, NH_3^-N, NO_3, PO_4, and SO_4 increased in the wet season. From the study, it could be recommended that the main reasons behind the contamination of Tasik Chini are anthropogenic activities such as agriculture, illegal logging, and unhygienic defecation. Flood flash from the Pahang River during the rainy season increased the TDS and nutrient value in the Tasik Chini water body. Overall, the water of the lake system stands in class II based on WQI, which could be used after conventional treatment. This study also found that the knowledge and attitude of the local community about the water quality of the lake was at a medium level, while the management practices were low. This study attempted to find out some factors influencing public perception of water quality and better public knowledge regarding the pollution sources. Survey results also revealed that the level of knowledge influenced public awareness behavior and human practices in nature conservation management. The policymaker may use the results and better understanding of public perception subsequently to improve the water quality system and protect the local community.

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