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Correlation coefficients (R-values) as potential indicators of water quality deterioration for the tropical urban lakes

Abstract

This study demonstrates the possible application of correlation coefficient (*R*-values) to reflect the water quality status of tropical urban lakes. Ten water quality parameters were measured from contaminated and unpolluted urban lakes at Kelana Jaya, Malaysia. The correlation analysis on the water quality parameters revealed that the polluted lake had higher numbers of significant correlation coefficients with highly significant levels of P< 0.001, attributable to the broader ranges of water quality metrics acquired from the former. This work provides baseline evidence for the potential use of *R*-values as prospective markers of water quality degradation in tropical urban lakes.

Keywords: water quality, statistical analysis

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Introduction

Generating data and evidence of a contaminated environment is the primary responsibility of ecotoxicologists assessing environmental pollution. Data from various field observations in the polluted sites have indicated that high levels and wide variations of pollutant concentrations for organisms and abiotic components (particularly water quality) are characteristic of highly anthropogenic locations,[1] although this may not be necessarily the result of human activities.[2] Nonetheless, such assumptions are occasionally based solely on high metal concentrations and broad ranges of environmental contaminant levels. Despite its ecotoxicological significance, data interpretation may be seen as another report on environmental quality. Therefore, more statistically-based evidence is necessary to prove that the ecosystem is being contaminated. Previously,[3] established that correlation coefficients (*R*-values) could be potential markers for heavy metal-contaminated sediments. However, precautionary efforts must be taken to ensure that monitoring studies adequately reflect the environmental quality of the entire ecosystem, from effluent-receiving point sources to distant, cleaner offshore sites. To date, however, such water quality assessments have never been published.

Correlation can be defined as the level of relationship between two variables.[4] The *R*-values can take on almost any value between -1 and 1, so caution is required when evaluating the *R*-value.[5] If a heavily contaminated area produces an exceptionally high level of metals, these cases are statistically considered to be anomalies. Since we recognise that these outliers result from human activity, these points should not be neglected.[4] Therefore, this study was conducted to provide baseline evidence for the potential use of *R*-values as prospective markers of water quality degradation in a tropical urban lake ecosystems. The ten-water quality analysed parameters were collected from both contaminated and unpolluted lakes in the urban area of Kelana Jaya, Peninsular Malaysia, and evaluated the potential use of *R*-values as indicators of water quality deterioration in the area.

Materials and methods

Surface water quality parameters and dissolved heavy metals in the water samples from Kelana Jaya lakes were collected during four consecutive periods: May 8, June 5, October 13, and November 1.[6] Sampling stations were situated at the inlet, centre, and exit of the contaminated and unpolluted lakes in Kelana Jaya (referred to as Lake 1 and Lake 3, respectively as shown in Figure 1).[6] The surface water samples for the measurement of orthophosphate, nitrate, ammonium, and total dissolved Cadmium, Copper, and Zinc were collected and transferred to the laboratory, while the temperature, conductivity, pH (potential hydrogen), and DO (dissolved oxygen) were measured '*in-situ*' with a YSI 556 MPS (Multi-Probe System). The detailed analytical protocols for orthophosphate, nitrate, ammonium were described in our previous study by Yap et al.[6] based on the Standard Methods for the Examination of Water and Wastewater.[7] For the analysis of total dissolved Cadmium, Copper, Zinc, an air-acetylene atomic absorption spectrophotometer (Perkin-ElmerTM, model AAnalyst800) was used. Spearman's correlation analysis was performed on the datasets for the two distinct lakes using the Statistical Analysis System (SAS) for Windows, Release 6.12.

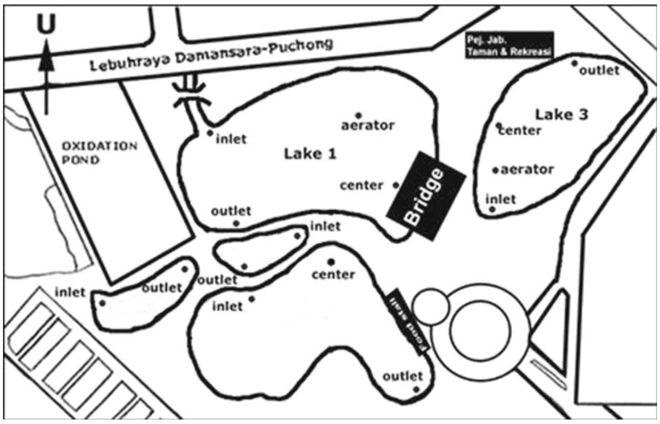

Figure 1 Sampling Map adopted from Yap et al.[6]

Results

Tables 1 and 2 demonstrate Spearman's correlation coefficients between the water quality indicators and dissolved heavy metals of the two lakes. According to Table 1, there are 22 significant correlation coefficients for Kelana Jaya's polluted lake (Lake 1). Seven of the 22 significant association coefficients for the polluted lake have P<0.05, five have P<0.01, and ten have P<0.001. From Table 2, it is evident that for the unpolluted lake at Kelana Jaya (Lake 3), ten of the 17 significant correlation coefficients have P<0.05, two have P<0.01, and five have P<0.001. Table 3 presents the overall comparisons of significant *R*-values.

Table 1 Spearman's correlation coefficients of water quality parameters and dissolved heavy metals in the waters of polluted lake at Kelana Jaya (Lake 1), collected during four consecutive sampling periods. N=36

Variables	Cd	Cu	Zn	Phos	Nit	Amm	Temp	pH	Cond	DO
Cd	1	0.79***	0.22ns	-0.34*	-0.64***	-0.42**	-0.36*	-0.24ns	0.16ns	-0.73***
Cu		1	0.12ns	-0.34*	-0.60***	-0.11ns	-0.56***	-0.23ns	-0.02ns	-0.48**
Zn			1	-0.09ns	-0.17ns	-0.28ns	0.17ns	0.21ns	0.14ns	-0.20ns
Phos				1	0.09ns	0.37*	0.15ns	-0.54***	0.27ns	-0.03ns
Nit					1	0.48**	0.23ns	0.46**	-0.36*	0.78***
Amm						1	-0.41*	-0.26ns	-0.10ns	0.52**
Temp							1	0.53***	-0.18ns	0.08ns
pH								1	-0.66***	0.49*
Cond									1	-0.52***
DO										1

Note: Phos: phosphate, Nit: nitrate, Amm: ammonia, Temp: temperature, Cond: conductivity, DO=dissolved oxygen. Values given are the correlation coefficients (r) and their levels of significance (ns=p>0.05, *=p<0.05, **=p<0.01, ***=p<0.001).

Table 2 Spearman's correlation coefficients water quality of unpolluted lake at Kelana Jaya (Lake 3), collected during four consecutive sampling periods. N=36

Variables	Cd	Cu	Zn	Phos	Nit	Amm	Temp	pH	Cond	DO
Cd	1	-0.18ns	-0.28ns	-0.13ns	-0.66***	-0.51**	0.07ns	-0.04ns	-0.03ns	-0.61***
Cu		1	0.02ns	0.07ns	0.08ns	-0.40*	-0.20ns	0.09ns	-0.05ns	0.28ns
Zn			1	-0.34*	-0.10ns	-0.26ns	0.32ns	0.14ns	-0.24ns	0.41*
Phos				1	0.38*	0.31ns	-0.35*	-0.33ns	0.36*	-0.30*
Nit					1	0.73***	-0.52**	-0.33*	0.10ns	-0.03ns
Amm						1	-0.16ns	-0.31ns	0.30ns	-0.16ns
Temp							1	0.63***	0.17ns	0.42*
pH								1	-0.42*	0.55***
Cond									1	-0.16ns
DO										1

Note: Phos: phosphate, Nit: nitrate, Amm: ammonia, Temp: temperature, Cond: conductivity.

Values given are the correlation coefficients (r) and their levels of significance (ns=p>0.05, *=p<0.05, **=p<0.01, ***=p<0.001).

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Table 3 Comparison of numbers of significant correlation coefficients of water quality (N= 36) between polluted lake (Lake 1) and unpolluted lake (Lake 3) at Kelana Jaya

Category		Polluted lake (Lake 1)	Unpolluted lake (Lake 3)
Not significant	nsp>0.05	23	28
Significant	*p<0.05	7	10
	**p<0.01	5	2
	***p<0.001	10	5

Note: Total pairwises are 45, as shown in Tables 1 and 2.

Discussion

According to the findings of Yap et al.[6] regarding the water quality of the Kelana Jaya Lakes, Lake 1 was considered to be polluted, whereas Lake 3 was considered unpolluted. Lake 1 had the lowest pH (more acidic) and highest conductivity (0.42 mS/cm) compared to the other lakes. This could result from inputs from the monsoon drain and the adjoining oxidation pond. Compared to other lakes, Lake 1 had elevated concentrations of ammonia, nitrate, and phosphate. This explains why Lake 1 had the greatest conductivity. Lake 1 also has the lowest DO (0.761 mg/L), attributed to a high nitrogen-rich fertiliser load. The greatest concentrations of Cadmium, Copper, and Zinc in Lake 1 were caused by the linked primary drainage system,[8] which conveyed untreated or partially treated discharges from neighbouring areas.[9] Due to the presence of an aerator, Lake 3 was considered to be the cleanest lake, despite having the highest DO concentration (8.712 mg/L). Cadmium, Copper, and Zinc were unexpectedly found in Lake 3 due to domestic runoff from the surrounding lands via the monsoon drainage system.[9,10]

Based on the ten water quality parameters and three levels of heavy metals in the surface sediment of the two distinct urban lakes, it was evident that the polluted lake had a greater number of significant correlation coefficients, with higher significance levels at P<0.001. This could be because the polluted lake had a larger range of water quality parameter values and metal concentrations in sediments than the unpolluted lake. Statistical calculations that overlook statistical correlations might lead to erroneous findings and improper conclusions.[11] Nevertheless, Asuero et al.[4] argued that a statistical measure of link, such as an *R*-value, should never be used to infer a causative relationship, and that reasoning on causation must come from outside statistics.[4]

To accurately assess the ecosystem's total environmental quality, it is necessary to perform unbiased sampling. Moreover, extra caution should be taken to ensure that the sampling of environmental parameters is appropriately designed and covers the entire ecosystem, from effluent-receiving point sources to clean sites located a distance from the sources. The application of the *R*-value as an indicator of environmental quality is highly possible if the aforementioned requirements are met. Nevertheless, it is also important to consider any false correlations - the reported connection between two variables may be due to the influence of a third, unobserved variable excluded in the study. Consequently, the low number of *R*-values in the metal-polluted ecosystem is likely attributable to undocumented and unstudied biotic and abiotic variables.

Conclusion

The present study revealed the *R*-values' potential to indicate the deterioration of water quality in the ecology of urban tropical lakes. Despite the fact that some published research supported the current concept, some reported studies did not support the use of *R*-values, indicating the presence of a third variable not considered in the study. The present finding can be recommended to be used as a simple indicator of water quality deterioration in the tropical lake ecosystem, even though additional research is necessary to include other physic-chemical parameters to confirm its reliability and applicability.

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Conflicts of interest

The author declares there is no conflict of interest.

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