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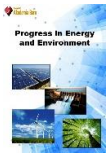

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Case study

Strategies for improvement of water quality in urban lakes

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Farah Amira Ahmad Shafee[1], Nasir Shafiq[1], Syed Ahmad Farhan[2,*]

[1] Department of Civil and Environmental Engineering, Universiti Teknologi PETRONAS, Seri Iskandar 32610, Malaysia
[2] Institute of Self-Sustainable Buildings for Smart Living, Universiti Teknologi PETRONAS, Seri Iskandar 32610, Malaysia
[*] **Correspondence email:** syed.af_g02626@utp.edu.my

Abstract

Urban lakes play a crucial role in maintaining ecological balance and improving environmental conditions within cities. They also contribute to socio-economic development by providing recreational opportunities and attracting visitors. However, there are many issues that lead to adverse effects on the water quality in the lakes. Strategies to improve the water quality have to be identified. Implementation of the strategies is dependent on the support from construction professionals. Therefore, in the present study, the levels of support towards the implementation of the strategies are investigated by means of a questionnaire survey among construction professionals. Results revealed that, draining the lake to clean out accumulated waste, pumping in clean water to artificially raise the water level, and planting more shoreline vegetation, obtained the highest levels of support. They also highlighted the importance of implementing a combination of the strategies for a successful overall improvement in the water quality.

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1 Introduction

Lakes play a crucial role in the urban ecosystem. They contribute towards maintaining biodiversity and ecological balance [1], as well as influencing the air temperature and humidity hence improving environmental conditions within cities [2]. Furthermore, they provide recreational opportunities and offer aesthetic value and cultural significance, hence attracting visitors and contributing to socio-economic development.

However, rapid urban expansion and the associated pollution from human activities pose significant challenges to maintaining water quality in urban lakes [3]. Pollutants, such as sewage, industrial waste and agricultural runoff, can accumulate in the lakes, leading to adverse effects on the water quality. Eutrophic conditions, characterized by excessive nutrient enrichment and algal blooms, are common in urban lakes due to the influx of nutrients from surrounding urban areas. The conditions can lead to a decrease in dissolved oxygen levels, harming aquatic organisms and disrupting the balance of the lake ecosystem [4]. Additionally, degradation of riparian vegetation along urban lakeshores can exacerbate water quality issues by contributing to sedimentation and nutrient runoff. The heightened sedimentation and nutrient runoff can lead to increased turbidity, decreased water clarity and proliferation of harmful algal blooms.

Therefore, understanding and mitigating environmental stressors that affect urban lakes has become a crucial area of research for environmental scientists and policy makers alike. It is imperative that environmental conditions are monitored and assessed regularly to ensure sustainable management of the lakes. Regular monitoring and assessment of the lakes can help identify the emerging stressors and

their impacts on the ecosystem [5]. Thus, it can aid in designing effective management strategies tailored to specific environmental conditions of each lake and ultimately promoting its ecological and social values. Furthermore, involvement of local communities in the management and restoration processes can also contribute to building social cohesion, promoting environmental awareness and education, and enhancing the sustainability of urban lakes [6].

In view of the issues that lead to adverse effects on the water quality in urban lakes, strategies to improve the water quality have to be identified to enable the lakes to play their role in the urban ecosystem. Furthermore, implementation of the strategies is dependent on the support from construction professionals. Lack of the support could hinder the implementation hence, sufficient improvement in the water quality could be difficult to attain. Therefore, in the present study, the levels of support towards the implementation of the strategies are investigated by means of a questionnaire survey among construction professionals. Findings of the survey will shed light on the strategies that have to be given more focus on and higher priority in improving the water quality as well as the strategies that may require additional efforts with regard to increasing interest and awareness and gathering support to facilitate their implementation.

2 Methodology

Strategies that can improve water quality in urban lakes were identified from the research literature. Levels of support among construction professionals towards the implementation of the strategies were investigated by means of a questionnaire survey. A questionnaire was designed using a 5-point Likert scale, with 5 indicating strong agreement, 4 indicating agreement, 3 indicating neutral agreement, 2 indicating disagreement and 1 indicating significant disagreement.

The questionnaire was disseminated to construction professionals from the public and private sectors in Australia and Malaysia by means of a random sampling. All respondents are above 18 years of age. A pilot survey was conducted prior to disseminating the questionnaire to test its clarity, comprehensiveness and practicality. A total of 320 responses were obtained. The data was statistically analyzed using Statistical Package for Social Sciences.

The normality of the data was assessed by determining the skewness and kurtosis. Skewness measures the symmetry of the data distribution as shown in Eq. (1) for univariate data, X_1, X_2, ⋯, X_N. Kurtosis measures whether the data are heavy- or light-tailed relative to a normal distribution as shown in Eq. (2). The mean and standard deviation of the data were determined with the aim of ranking the levels of support towards the implementation of the strategies.

$$\text{Skewness} = \frac{\sum_{i=1}^{N}\left(X_i - \bar{X}\right)^3}{(N-1)\sigma^3} \tag{1}$$

$$\text{Kurtosis} = \frac{\sum_{i=1}^{N}\left(X_i - \bar{X}\right)^4}{N\sigma^4} \tag{2}$$

where N is the number of variables in the distribution, X_i is the i^{th} random variable, $\bar{X}$ is the mean of the distribution and σ is the standard deviation.

The internal consistency of the data collected from the survey were assessed by means of a reliability test to ensure that the items in the questionnaire were stable and produced consistent and reliable data. The internal consistency was measured by determining the Cronbach's Alpha [7], which compares the amount of covariance among the items in the questionnaire to the amount of overall variance as shown in Eq. (3).

$$\alpha = \frac{k\bar{c}}{\bar{v} + (k-1)\bar{c}} \tag{3}$$

where α is the Cronbach's alpha, k is the number of items, $\bar{c}$ is the average inter-item covariance and $\bar{v}$ is the average variance.

3 Results and Discussion

Table 1 lists the strategies that can improve water quality in urban lakes. IDs are assigned to each strategy to facilitate data analysis. The strategies include biological, chemical and physical methods. Biological methods involve the use of biological agents, such as bacteria, plants and algae, to remove and degrade pollutants in water. Chemical methods involve the addition of chemicals to water to neutralize pollutants and promote sedimentation. Physical methods, such as water diversion, can also be adopted to improve water quality in lakes.

Table 1 Strategies that can improve water quality in urban lakes

ID	Strategy
S1	Planting more shoreline vegetation, such as reeds
S2	Draining the lake to clean out accumulated waste
S3	Banning public use of the water body for sport and fishing
S4	Installing floating islands of aquatic plants
S5	Filling in the lake and converting it to a public park or green space
S6	Pumping in clean water to artificially raise the water level
S7	Introducing a virus to kill the carp (exotic fish) in the lake
S8	Adding chemicals, such as algae control agents, to clean the water
S9	Leaving the lake as it is and not changing anything

Most respondents agree that the declining water quality of urban lakes is a growing concern. Results of the data analysis as revealed in Table 2 indicate that *draining the lake to clean out accumulated waste* (S2) is the most supported strategy with the highest mean value of 3.94 supported by a standard deviation of 0.995, which is higher than that of S6, which has an identical mean value to that of S2. *Pumping in clean water to artificially raise the water level* (S6) and *planting more shoreline vegetation, such as reeds* (S1) are the second- and third-most supported strategies with mean values of 3.94 and 3.89. The least supported strategies are *adding chemicals, such as algae control agents, to clean the water* (S8), *introducing a virus to kill the carp (exotic fish) in the lake* (S7) and *leaving the lake as it is and not changing anything* (S9) with mean values of 3.34, 3.29 and 3.16, respectively. The findings also highlighted the importance of implementing a combination of the strategies for a successful overall improvement in the water quality. The negative or positive values for skewness and kurtosis do not represent any issue as they are within the normal range. The mixture of negative or positive values indicates the underlying nature of the constructs being measured.

Table 2 Ranking on levels of support towards the implementation of the strategies

Rank	Strategy ID	Mean	Standard Deviation	Skewness		Kurtosis	
				Value	Standard Error	Value	Standard Error
1	S2	3.94	0.995	-0.774	0.205	-0.001	0.407
2	S6	3.94	0.915	-0.843	0.205	0.611	0.407
3	S1	3.89	0.968	-1.072	0.205	1.259	0.407
4	S4	3.81	1.015	-1.126	0.205	1.171	0.407
5	S5	3.67	1.214	-0.861	0.205	-0.078	0.407
6	S3	3.65	1.163	-0.649	0.205	-0.297	0.407
7	S8	3.34	1.186	-0.511	0.205	-0.590	0.407
8	S7	3.29	1.248	-0.419	0.205	-0.843	0.407
9	S9	3.16	1.380	-0.320	0.205	-1.147	0.407

One of the most supported approaches to improve lake water quality is the drainage and cleaning out of accumulated waste, as suggested by respondents in the study with a mean value of 3.94 and a standard deviation of 0.995. This approach involves removing the accumulated sediment and pollutants from the bottom of the lake, ultimately resulting in an improvement in water quality [6]. The second and third most supported approaches involve increasing the water level artificially by pumping in clean water and planting more shoreline vegetation, such as reeds. These approaches have mean values of 3.94 and 3.89 respectively, indicating that they are also important to lake water quality improvement.

Furthermore, the implementation of effective monitoring programs is crucial to determine the most appropriate approach for lake restoration and management [8].

The value of Cronbach's Alpha of 0.798 obtained from the assessment of the internal consistency of the data as shown in Table 3 implies that the items in the questionnaire have a high level of internal consistency. Respondents who seek to select high ratings for one item generally do so for other items. The result indicates that the questionnaire produced consistent and reliable data hence confirming its validity.

Table 3 The variable of lake contribution factors

Construct	Number of Items	Cronbach's Alpha
Rank of the issues pertaining to lake management that lead to adverse effects on water quality	31	0.798

4 Conclusion

A questionnaire survey was conducted among construction professionals to investigate the levels of support towards the implementation of the strategies to improve the water quality of urban lakes. Findings reveal that most respondents agree that the declining water quality of urban lakes is a growing concern. Results revealed that, draining the lake to clean out accumulated waste, pumping in clean water to artificially raise the water level, and planting more shoreline vegetation, obtained the highest levels of support. They also highlighted the importance of implementing a combination of the strategies for a successful overall improvement in the water quality.

The levels of support for the strategies vary depending on the country and stakeholders involved. In essence, the strategies promote sustainable water management practices. Therefore, there is a general consensus among stakeholders that implementation of the strategies is crucial in minimizing water quality issues and ensuring the long-term sustainability of lake ecosystems.

Lake water quality is a critical issue that affects the health of both humans and ecosystems. Failing to address issues that contribute to poor lake water quality can have devastating consequences, including toxic algae blooms, fish kills, and threats to human health. Human activities such as industrial pollution, agricultural runoff, tourism, and construction of barriers in lakes have led to an increase in organic and inorganic pollutants that severely degrade water quality.

Ensuring good lake water quality is essential for preserving aquatic life and mitigating the risk of negative health effects caused by high concentrations of harmful chemicals in the water. It is clear that there are various methods to improve lake water quality and prevent the loss of ecosystem services provided by aquatic ecosystems.

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Declaration of Conflict of Interest

The authors declared that there is no conflict of interest with any other party on the publication of the current work.

ORCID

Farah Amira Ahmad Shafee https://orcid.org/0000-0002-7276-5091

Nasir Shafiq https://orcid.org/0000-0002-9496-5430

Syed Ahmad Farhan https://orcid.org/0000-0001-6970-9083

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