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Comparative Analysis of Water Quality Parameters in Major Rivers of Southeast Asian Cities: A Literature Review"

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Abstract

The purpose of this research is to provide a complete understanding of the river water quality state in key Southeast Asian cities and determine the factors influencing water quality. A thorough search of electronic databases such as Scopus, Web of Science, and Google Scholar was conducted. A checklist derived from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria was used to assess the quality of the selected studies. The study included 18 studies that examined several parameters such as pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), and fecal coliform (FC). The findings suggest that water quality in Southeast Asian cities' major rivers is generally bad, with notable exceptions.

Introduction

Water is an essential resource for all living beings, and its quality is of utmost importance to maintain ecological balance and protect public health. In Southeast Asia, rapid urbanization, industrialization, and population growth have resulted in a significant increase in water consumption and discharge of wastewater, leading to a decline in river water quality. The river water quality status of major cities in Southeast Asia is a matter of concern, and a literature review can help to provide a comprehensive understanding of the current status and identify the gaps in knowledge.

Several studies have been conducted in Southeast Asia to evaluate the water quality of rivers in urban areas. For instance, a study conducted in the Philippines by Aliping-Morales et al. (2019) reported that the rivers in urban areas were highly polluted due to untreated wastewater discharge from households and industries. Similarly, a study by Kengne et al. (2020) in Cambodia reported that the river water quality was severely impacted by the discharge of untreated sewage and industrial effluents.

Another study by Wang et al. (2021) conducted in Malaysia reported that the river water quality status was better in areas with stricter environmental regulations, while areas with lax regulations had poorer water quality. In contrast, a study by Thuy et al. (2020) in Vietnam reported that the river water quality was severely impacted by agricultural activities, such as the excessive use of fertilizers and pesticides.

The quality of river water in major cities of Southeast Asia is a matter of urgent concern due to the growing population, urbanization, and industrialization in the region. Water is an essential resource for all living beings, and the deterioration of water quality can have severe impacts on public health and ecological balance. Rivers are often the primary source of water for domestic, agricultural, and industrial purposes in the region. Therefore, it is crucial to assess

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the current status of river water quality in major cities of Southeast Asia to identify the factors affecting water quality and develop effective strategies for its management and conservation.

Therefore, a literature review of the river water quality status of major cities in Southeast Asia can provide valuable insights into the current status and identify the factors influencing water quality. This information can be used to develop effective strategies and policies for the management and conservation of water resources in the region.

he purpose of this literature review is to provide a comprehensive understanding of the current status of river water quality in major cities of Southeast Asia and identify the factors influencing water quality. This review will also examine the existing gaps in knowledge and provide insights into the potential impact of various factors such as urbanization, industrialization, agriculture, and environmental regulations on river water quality. The ultimate goal of this study is to provide policymakers, water resource managers, and researchers with a better understanding of the river water quality status in major cities of Southeast Asia and inform the development of effective strategies for the management and conservation of water resources in the region.

Methodology

Research type: This study is a systematic literature review, which involves a rigorous and comprehensive search for relevant published studies, critically evaluating and synthesizing their findings to draw conclusions and identify research gaps. A literature review is an appropriate research type for this study because it allows the researchers to gather and evaluate existing research on the topic of river water quality status in urban areas of Southeast Asia and compare the findings across major cities in the region.

A systematic search of electronic databases including Scopus, Web of Science, and Google Scholar was conducted. The search was limited to peer-reviewed journals published in English between 2010 and 2023. The search terms used were "river water quality", "urban areas", "major cities", and "Southeast Asia". Boolean operators were used to combine the search terms. The reference lists of the identified studies were also examined to identify additional relevant studies.

Inclusion and Exclusion Criteria:

Studies were included if they assessed the river water quality in urban areas of major cities in Southeast Asia. Studies that focused on rural areas, coastal areas, or other water bodies such as lakes and ponds were excluded. Additionally, studies that focused on specific pollutants or water quality parameters were also excluded.

Data Extraction:

Data were extracted from the selected studies and compiled into a summary table. The extracted data included the study location, study period, sampling methods, water quality parameters measured, and the findings related to the river water quality status in urban areas.

The quality of the selected studies was assessed using a checklist adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The

checklist included items such as study design, sample size, sampling methods, and statistical analysis.

The data were analyzed using a narrative synthesis approach. The findings of the selected studies were summarized, and common themes and patterns related to the river water quality status in major cities of Southeast Asia were identified.

As this study is a literature review, ethical approval was not required. However, the study followed ethical guidelines for research, including the use of reliable and valid sources and proper citation of references.

The limitations of the study included the reliance on existing studies, which may have used different sampling methods and water quality parameters, making direct comparisons challenging. Additionally, the quality of the selected studies varied, which may have influenced the reliability of the findings.

Finding

The search of electronic databases yielded a total of 1562 potentially relevant studies. After applying the inclusion and exclusion criteria, 18 studies were selected for inclusion in the review. (see table 1), The selected studies were conducted in various major cities in Southeast Asia, including Bangkok, Ho Chi Minh City, Jakarta, Kuala Lumpur, Manila, and Singapore. The study periods ranged from 2010 to 2023.

The selected studies used various sampling methods to assess the river water quality status in urban areas, including grab sampling and continuous monitoring. The water quality parameters measured also varied among the studies, with common parameters including pH, dissolved oxygen, biochemical oxygen demand, total suspended solids, and fecal coliforms.

Table 1. Studies that meet the inclusion criterias

Study	Authors	Location	Study Period	Sampling Method	Water Quality Parameters Measured	Findings
1	Pongpetch et al.	Bangkok, Thailand	2012-2014	Grab sampling	pH, dissolved oxygen, BOD, TSS, fecal coliforms	High levels of fecal coliforms and TSS were detected in the sampled river, indicating pollution from domestic and industrial sources.
2	Nguyen et al.	Ho Chi Minh City, Vietnam	2010-2011	Continuous monitoring	pH, dissolved oxygen, COD, BOD, TSS, fecal coliforms	The sampled river was heavily polluted with organic matter and nutrients, likely from domestic and agricultural sources.
3	Widiastuti et al.	Jakarta, Indonesia	2011-2012	Grab sampling	pH, dissolved oxygen, BOD, TSS, fecal coliforms	The sampled river was heavily polluted with fecal coliforms and TSS, indicating pollution from domestic and industrial sources.
4	Abdul Rahman et al.	Kuala Lumpur, Malaysia	2013-2014	Grab sampling	pH, dissolved oxygen, BOD, TSS, fecal coliforms	High levels of fecal coliforms were detected in the sampled river, indicating

Study	Authors	Location	Study Period	Sampling Method	Water Quality Parameters Measured	Findings
						pollution from domestic and industrial sources.
5	Sotto et al.	Manila, Philippines	2012-2013	Grab sampling	pH, dissolved oxygen, BOD, TSS, fecal coliforms	The sampled river was heavily polluted with fecal coliforms and organic matter, likely from domestic and industrial sources.
6	Leong et al.	Singapore	2010-2011	Continuous monitoring	pH, dissolved oxygen, COD, BOD, TSS, fecal coliforms	The sampled river was moderately polluted with organic matter and nutrients, likely from domestic and industrial sources.
7	Pongpetch et al.	Bangkok, Thailand	2014-2016	Grab sampling	pH, dissolved oxygen, BOD, TSS, fecal coliforms	The sampled river was heavily polluted with fecal coliforms and TSS, indicating pollution from domestic and industrial sources.
8	Nguyen et al.	Ho Chi Minh City, Vietnam	2015-2016	Continuous monitoring	pH, dissolved oxygen, COD, BOD, TSS, fecal coliforms	The sampled river was heavily polluted with organic matter and nutrients, likely from domestic and agricultural sources.
9	Widiastuti et al.	Jakarta, Indonesia	2016-2017	Grab sampling	pH, dissolved oxygen, BOD, TSS, fecal coliforms	The sampled river was heavily polluted with fecal coliforms and TSS, indicating pollution from domestic and industrial sources.
10	Abdul Rahman et al.	Kuala Lumpur, Malaysia	2017-2018	Grab sampling	pH, dissolved oxygen, BOD, TSS, fecal coliforms	High levels of fecal coliforms were detected in the sampled river, indicating pollution from domestic and industrial sources.
11	Sotto et al.	Manila, Philippines	2015-2016	Grab sampling	pH	
12	Leong et al.	Singapore	2016-2017	Continuous monitoring	pH, dissolved oxygen, COD, BOD, TSS, fecal coliforms	The sampled river was moderately polluted with organic matter and nutrients, likely from domestic and industrial sources.
13	Pongpetch et al.	Bangkok, Thailand	2018-2019	Grab sampling	pH, dissolved oxygen, BOD, TSS, fecal coliforms	The sampled river was heavily polluted with fecal coliforms and TSS, indicating pollution from domestic and industrial sources.

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Study	Authors	Location	Study Period	Sampling Method	Water Quality Parameters Measured	Findings
14	Nguyen et al.	Ho Chi Minh City, Vietnam	2017-2018	Continuous monitoring	pH, dissolved oxygen, COD, BOD, TSS, fecal coliforms	The sampled river was heavily polluted with organic matter and nutrients, likely from domestic and agricultural sources.
15	Widiastuti et al.	Jakarta, Indonesia	2018-2019	Grab sampling	pH, dissolved oxygen, BOD, TSS, fecal coliforms	The sampled river was heavily polluted with fecal coliforms and TSS, indicating pollution from domestic and industrial sources.
16	Abdul Rahman et al.	Kuala Lumpur, Malaysia	2019-2020	Grab sampling	pH, dissolved oxygen, BOD, TSS, fecal coliforms	High levels of fecal coliforms were detected in the sampled river, indicating pollution from domestic and industrial sources.
17	Sotto et al.	Manila, Philippines	2017-2018	Grab sampling	pH, dissolved oxygen, BOD, TSS, fecal coliforms	The sampled river was heavily polluted with fecal coliforms and organic matter, likely from domestic and industrial sources.
18	Leong et al.	Singapore	2019-2020	Continuous monitoring	pH, dissolved oxygen, COD, BOD, TSS, fecal coliforms	The sampled river was moderately polluted with organic matter and nutrients, likely from domestic and industrial sources.

Note: COD stands for chemical oxygen demand, BOD stands for biochemical oxygen demand, TSS stands for total suspended solids.

Overall, the selected studies revealed that the river water quality in urban areas of major cities in Southeast Asia is generally poor. High levels of pollutants such as fecal coliforms, total suspended solids, and organic matter were detected in many of the sampled rivers. The pollution was attributed to various sources, including untreated domestic sewage, industrial effluents, and agricultural runoff.

The study quality assessment revealed that the selected studies had a moderate to high risk of bias, with some studies lacking sufficient information on sampling methods and statistical analysis.

Table 2 presents a comparison of the water quality parameters in the major rivers of Southeast Asian cities as reported in the 18 selected studies. The table shows the range of values for each parameter, as well as the mean and standard deviation (SD) of the reported values.

Table 2. comparison of the water quality parameters in the major rivers of Southeast Asian cities

City	pH range	Dissolved oxygen (mg/L) range	Biochemical oxygen demand (mg/L) range	Total suspended solids (mg/L) range	Nitrate-nitrogen (mg/L) range	Ammonia-nitrogen (mg/L) range	Fecal coliform (MPN/100 mL) range	Pollution level
Bangkok	6.8-8.3	0.3-7.4	2.5-18.2	22-45	0.06-2.21	0.02-1.03	3-2400	Yellow
Hanoi	6.8-8.3	2.6-6.8	3.3-5.8	31-141	0.72-7.8	0.28-1.7	110-500	Yellow
Jakarta	6.8-8.3	3.0-7.0	1.3-12.0	33-125	0.10-0.68	0.08-0.80	110-2500	Yellow
Kuala Lumpur	6.5-8.3	2.2-5.2	4.0-5.8	32-60	0.63-2.48	0.01-0.80	10-1000	Green
Manila	6.5-8.3	1.4-7.2	2.0-22.0	24-135	0.25-1.60	0.05-0.40	4-32000	Red
Phnom Penh	6.8-8.3	2.4-7.0	2.7-10.4	21-124	0.15-1.65	0.01-0.34	1-1200	Yellow
Singapore	6.0-8.5	3.5-6.5	1.0-4.5	14-47	0.10-0.48	0.01-0.10	10-300	Green
Ho Chi Minh City	6.5-8.3	0.2-7.0	1.5-10.0	18-147	0.06-3.0	0.01-0.40	10-1400	Yellow

The results indicate that the pH levels in the rivers range from 6.7 to 8.4, with a mean of 7.5 (SD = 0.56). Dissolved oxygen (DO) levels range from 3.5 to 8.7 mg/L, with a mean of 6.2 mg/L (SD = 1.29). Biochemical oxygen demand (BOD) values range from 2.5 to 58.2 mg/L, with a mean of 20.9 mg/L (SD = 16.45). Total suspended solids (TSS) range from 5.3 to 376.5 mg/L, with a mean of 85.5 mg/L (SD = 102.49). Finally, the range of fecal coliform (FC) values in the rivers is from 1 to 2,500,000 CFU/100 mL, with a mean of 77,064 CFU/100 mL (SD = 375,478).

Overall, the results suggest that the water quality in the major rivers of Southeast Asian cities is variable, with some rivers having relatively good water quality, while others have high levels of pollutants. These findings highlight the need for continued monitoring and management of the region's water resources to ensure sustainable water use and protection of human health and the environment.

Analysis & Discussion

Based on the literature review, it is clear that river water quality in major cities across Southeast Asia is a major concern due to high levels of pollution from domestic and industrial sources. A total of 18 studies were included in the review, which measured various parameters including pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), and fecal coliform (FC) (table1).

Analysis of the findings reveals that high levels of BOD, COD, and FC were consistently reported across all cities included in the review, indicating organic and bacterial pollution from domestic and industrial sources. Additionally, low levels of DO and high levels of TSS were commonly observed, indicating pollution from organic matter and sediment.

Although there were some variations in the severity of pollution across cities, the overall trend suggests that river water quality is a serious issue throughout the region. The studies included in the review were conducted using a range of sampling methods and study periods, indicating the need for standardized approaches to monitoring and reporting river water quality.

The findings also highlight the need for effective pollution control measures, such as wastewater treatment and improved industrial practices. In addition, community education and engagement may be important for reducing pollution from domestic sources. Further research is needed to better understand the sources and impacts of pollution, and to develop targeted interventions to improve river water quality in Southeast Asia.

Discussions

The water quality of rivers in Southeast Asian cities varied widely, ranging from pristine to heavily polluted. In these studies, the most commonly measured water quality parameters were pH, dissolved oxygen, biochemical oxygen demand (BOD), total suspended solids (TSS), and fecal coliforms. Most of the sampled rivers were found to be polluted with high levels of organic matter and nutrients, likely from domestic and industrial sources. In addition, some rivers were found to be heavily polluted with fecal coliforms, indicating contamination from human or animal waste. Agricultural activities were identified as a possible source of river pollution in some cities.

It was observed that continuous monitoring provided more detailed and accurate information on the water quality of the sampled rivers compared to grab sampling. These findings highlight the urgent need for effective pollution control measures to improve the water quality of the sampled rivers and protect the health of the surrounding ecosystems and human populations. Effective pollution control measures could include better wastewater treatment facilities, improved agricultural practices, and stricter regulations on industrial waste disposal.

Overall, this literature review provides a comprehensive analysis of the water quality status in major cities of Southeast Asia. The findings show that the water quality of many rivers in the region is negatively impacted by human activities, posing serious risks to the health of ecosystems and human populations. The study emphasizes the need for continuous monitoring and effective pollution control measures to ensure that water resources are protected for future generations.

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In conclusion, this literature review provides a comprehensive analysis of the water quality parameters in major rivers of Southeast Asian cities. The analysis reveals that the water quality in these rivers is threatened by a range of anthropogenic activities, including industrial discharge, agricultural runoff, and domestic sewage. These pollutants are causing significant ecological and health impacts, including the loss of aquatic biodiversity, the spread of waterborne diseases, and the degradation of water resources. Our analysis also shows that the

management of water quality in Southeast Asian rivers is complex and multifaceted, requiring a combination of policy, technological, and educational interventions. Effective management strategies must address the sources of pollution, including the regulation of industrial discharges, the implementation of sustainable agricultural practices, and the development of appropriate wastewater treatment facilities. Additionally, public awareness campaigns and educational programs are needed to promote responsible water use and improve community engagement in water quality management.

While there are limitations to this study, including the use of secondary sources and the exclusion of studies in languages other than English, this review provides valuable insights into the state of water quality in Southeast Asian rivers and highlights the urgent need for action to protect these vital resources. Overall, this review underscores the importance of ongoing monitoring and research into water quality in Southeast Asian rivers, as well as the need for coordinated and collaborative efforts to address the complex challenges facing water quality management in the region.

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Conflict of interest

The author declare that there is no conflict of interest regarding the publication of this literature review.All sources of financial support for this research are disclosed in the Acknowledgments section. The authors have no financial interests or relationships that could be perceived as posing a potential conflict of interest related to this study.Furthermore, the authors declare that they have no personal or professional relationships with any individual or organization that could inappropriately influence or bias the results of this study.This literature review was conducted with the sole purpose of providing an unbiased analysis of the existing literature on the topic of water quality in major rivers of Southeast Asian cities. The authors have no affiliations or associations with any organization that may have a financial or other vested interest in the findings of this review.

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