Research Report

A Comparison of Long-Term Trends in the Physicochemical Water Quality of the Ping River in Chiang Mai Province

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Abstract

Research Project Title

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Curriculum: Water Quality, Ping River, Physicochemical Parameters, Temporal Changes, Water Quality Index (WQI)

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The water quality of the Ping River has changed over time and has been influenced by natural factors in combination with human activities. This study aimed to compare long-term trends in the physicochemical water quality of the Ping River in Chiang Mai Province using monitoring data collected under the GLOBE Program in 2007 and during the period 2019–2023. The parameters examined included water temperature, electrical conductivity, water transparency, and dissolved oxygen, together with an assessment of the Water Quality Index (WQI)

The results indicated that these parameters exhibited clear seasonal and spatial variations, particularly in urban areas where conductivity showed an increasing trend and water transparency declined. Meanwhile, the Water Quality Index in several locations tended to decrease to degraded levels when the two study periods were compared. The findings reflect pressures from urban expansion and land-use change on the river ecosystem and provide baseline information for water restoration planning, pollution control policy development, and sustainable long-term water-quality monitoring.

Keywords

Water Quality

Ping River

Physicochemical Water Quality

Temporal Changes

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Chapter 1
Introduction

Background and Significance of the Problem

The Ping River is a vital water resource for Chiang Mai Province, playing a major role in supporting the economy, agriculture, and surrounding ecosystems. However, rapid urban expansion and economic growth have significantly increased the risk of water-quality degradation. This research evaluates long-term trends in the physical and chemical properties of river water in order to monitor the extent to which human activities have affected the river ecosystem.

Although certain sections of the river continue to exhibit moderate environmental conditions, existing gaps in long-term datasets highlight the need for continuous and systematic water-quality monitoring. Ultimately, this study aims to provide a clear assessment of the river's ecological condition. The findings are expected to support sustainable environmental management and to raise public awareness of the importance of conserving this critical water resource for the future.

Research Questions

1. Which physical and chemical factors most strongly influence the water quality of the Ping River in Chiang Mai Province?

2. Do the long-term trends of increasing electrical conductivity and decreasing water transparency reflect the impacts of urban expansion in Chiang Mai Province on the overall health of the Ping River.

Research Hypotheses

1. Dissolved oxygen (DO) and electrical conductivity are the principal factors influencing water quality, as they are sensitive to pollution from urban areas and to seasonal temperature variation.

2. Long-term increases in electrical conductivity and decreases in water transparency are significantly associated with urban infrastructure expansion and population density in Chiang Mai Province, reflecting a deterioration in the overall health of the Ping River.

Research Objectives

      1. To investigate the impacts of human activities on the water quality of the Ping River.

      2. To evaluate long-term changes in the physicochemical water-quality parameters of the Ping River.

Expected Outcomes of the Research

      1. To identify long-term trends in the physicochemical water quality of the Ping River.

      2. To determine variations in water-quality conditions across different time periods.

      3. To provide data that can serve as a basis for future water-quality monitoring and conservation efforts.

Scope of the Study

Upper Reach of the Ping River

The upper reach includes Chor Lae Bridge and Ban Chor Lae in Mae Taeng District. This area is characterized primarily by rural landscapes and agricultural land use, with relatively low densities of built structures and human activities. Consequently, this section is expected to experience comparatively lower impacts on water quality than other areas.

Middle Reach of the Ping River

The middle reach comprises Pa Tan, Ban Wang Sing Kham Bridge, Mahidol Bridge, Pa Daet, and Tha Wang Tan Bridge in Mueang Chiang Mai District. Most of this area lies within urban communities and is characterized by dense infrastructure, heavy traffic, and extensive human activities, making it the section most likely to experience the greatest impacts on water quality.

Lower Reach of the Ping River

The lower reach includes the bridge in front of the Hang Dong Irrigation Hydrology Center Project in Hang Dong District and Nong Pla Sawai–Dong Hat Nak Bridge in Chom Thong District. This area consists of semi-urban and agricultural zones with diverse land uses, which are expected to influence water quality at a moderate level when compared with the upper and middle reaches

Chapter 2
Review of Related Literature and Research

This chapter reviews documents, concepts, theories, and previous studies related to the water quality of natural water bodies, with an emphasis on physicochemical water-quality parameters, principles for assessing river conditions using the Water Quality Index (WQI), and the role of the Global Learning and Observations to Benefit the Environment (GLOBE) Program in international environmental data collection. In addition, studies concerning community wastewater management and water-quality monitoring in northern watersheds were examined in order to provide a conceptual framework for interpreting the findings and to strengthen the reliability of the long-term trend analysis of the Ping River.

2.1 Concepts of Water Quality

Water quality refers to the characteristics of water that determine its suitability for use and for sustaining aquatic organisms. It can be assessed through physical, chemical, and biological parameters. Good water quality is typically indicated when measured values fall within established standards and do not adversely affect ecosystems or human health. Changes in water quality often result from both natural processes and human activities, such as urban expansion, agricultural practices, and wastewater discharge.

2.2 Physicochemical Water Quality

Physicochemical water quality is a critical component in evaluating the environmental condition of aquatic systems. Commonly studied parameters include water temperature, electrical conductivity, water transparency, and dissolved oxygen. These indicators reflect overall water conditions, cleanliness, and levels of pollution. Variations in these parameters are frequently associated with seasonal changes and local human activities.

2.3 The GLOBE Program and Water-Quality Monitoring

The Global Learning and Observations to Benefit the Environment (GLOBE) Program is an international environmental initiative that encourages students and the public to participate in standardized environmental measurements and data collection. Water-quality data generated through GLOBE can be used to investigate long-term trends in aquatic systems and serve as a valuable database for research and water-resource conservation.

2.4 Related Studies

Rungruangwong (2023) investigated the monitoring and evaluation of the effectiveness of communal and cluster wastewater treatment systems in Lamphun Municipality and reported that effective wastewater management can reduce negative impacts on water quality in natural water bodies. This study highlights the importance of controlling pollution sources associated with human activities.In addition, data from the GLOBE Program at the Nakornping Bridge monitoring station (SWS-03) indicate that the water quality of the Ping River has changed over time. These data can be used to support analyses of long-term water-quality trends and to compare findings from sites within Chiang Mai Province.

2.5 Summary of Related Literature and Research

The review of relevant literature and previous studies indicates that the water quality of natural water bodies is influenced by both natural factors and human activities. The integration of data collected through the GLOBE Program with findings from related research strengthens the credibility of this study and enables the results to be used as baseline information for long-term monitoring and conservation of water quality in the Ping River.

Chapter 3
Research Implementation

Study Sites

      1. The bridge in front of the Hang Dong Irrigation Hydrology Center Project, Hang Dong District

      2. Nong Pla Sawai–Dong Hat Nak Bridge, Chom Thong District

      3. Pa Daet–Tha Wang Tan Bridge, Mueang District

      4. Mahidol Bridge (near Region 5 Provincial Police Headquarters), Mueang District

      5. Pa Tan–Ban Wang Sing Kham Bridge, Mueang District

      6. Chor Lae Bridge, Ban Chor Lae, Mae Taeng District, Chiang Mai Province

Materials and Equipment

Materials and Equipment for Baseline Data Collection (2007)

      1. Thermometer

      2. Dissolved Oxygen (DO) meter

      3. Electrical Conductivity (EC) meter

      4. Water transparency tube

      5. Camera for documenting site conditions

      6. Mobile phones for recording data and coordinates

      7. Google Maps and Google Earth applications for location identification and environmental assessment

      8. Google Sheets for data recording and storage

Materials and Equipment for Supplementary Data Collection (2019–2023)

      1. Dissolved Oxygen (DO) meter

      2. Ammonia test kit

      3. Coliform test kit

      4. Coliform swab test kit

      5. Camera for documenting field conditions

      6. Mobile phones for recording field data\

      7. Google Maps and Google Earth applications

      8. Google Sheets for data storage and analysis

Research Procedures

This study investigated the water quality of the Ping River in Chiang Mai Province at six monitoring sites using data collected in 2007 and during the period 2019–2023 in accordance with the GLOBE Program protocols. The parameters examined included water temperature, electrical conductivity, water transparency, and dissolved oxygen. Google Earth was also employed to examine the environmental characteristics of the study areas. The data were subsequently analyzed and compared in order to identify long-term trends in water quality.

Chapter 4
Results

This chapter presents the findings on changes in the water quality of the Ping River in Chiang Mai Province based on historical and recent monitoring data collected under the GLOBE Program. The analysis focuses on key physicochemical parameters, including water temperature, electrical conductivity, water transparency, and dissolved oxygen, together with an assessment of the Water Quality Index (WQI) to reflect the overall condition of the river. The results are presented descriptively and through comparisons of temporal trends in order to illustrate long-term patterns of change, seasonal differences in water quality, and the influence of environmental conditions and human activities in different sections of the Ping River.

Year 2019


4.1 Trends in Electrical Conductivity

Data analysis revealed that electrical conductivity fluctuated throughout the year. During the early part of the year (January–March), values ranged from approximately 200 to 260 microsiemens per centimeter before declining toward the end of the first quarter. In the middle of the year (May–August), conductivity exhibited pronounced instability, varying between about 140 and 260 microsiemens per centimeter, which may be associated with rainfall amounts and surface runoff from surrounding areas. Toward the end of the year (September–November), conductivity reached its lowest level in September and then increased steadily to the annual maximum in November. These trends reflect the accumulation of dissolved substances and

minerals in the water, potentially resulting from community activities, land use, and wastewater discharges along the river corridor.
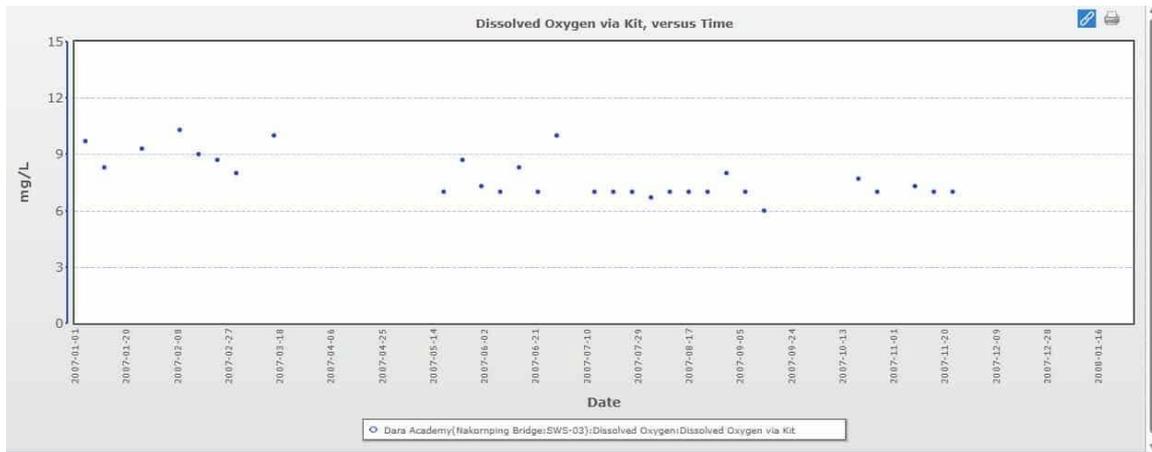

4.2 Trends in Dissolved Oxygen (DO)

Dissolved oxygen concentrations in the Ping River showed clear seasonal variation. In the early part of the year, DO levels were relatively high, approximately 8–10 milligrams per liter, indicating conditions favorable for aquatic life. However, during the middle of the year, DO tended to decline and stabilize within the range of 7–8 milligrams per liter, reaching the lowest levels in September. Reductions in dissolved oxygen may be associated with higher water temperatures and increased organic matter from human activities, which stimulate microbial decomposition processes and consequently reduce oxygen availability in the water, potentially affecting long-term ecosystem balance.
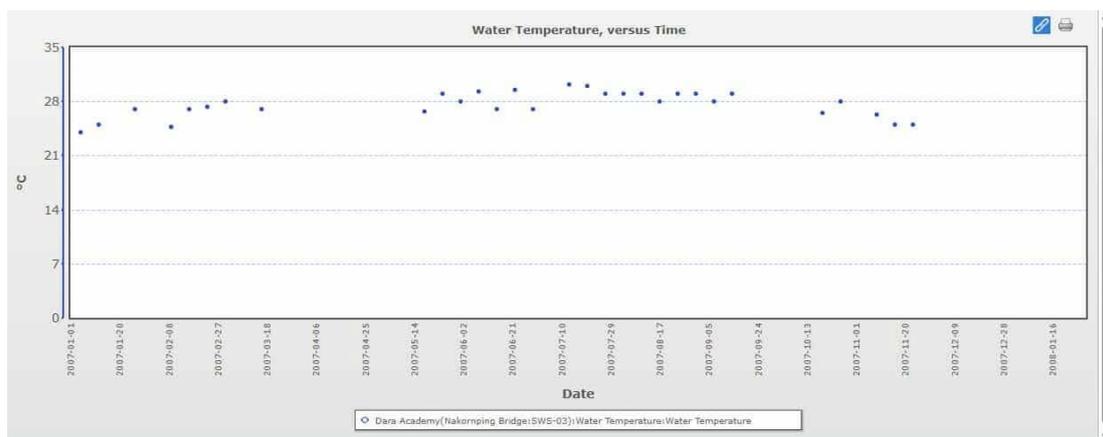
4.3 Changes in Water Temperature

Measurements of water temperature revealed a seasonal pattern consistent with climatic conditions. During the early part of the year, corresponding to the cool season, temperatures ranged from approximately 24–25°C before rising during the middle of the year, particularly in June and July, when average values reached about 30–31°C. Water temperatures then gradually declined toward the end of the year. This trend is important for overall water quality because temperature directly influences oxygen solubility and the rates of biochemical reactions within aquatic environments.
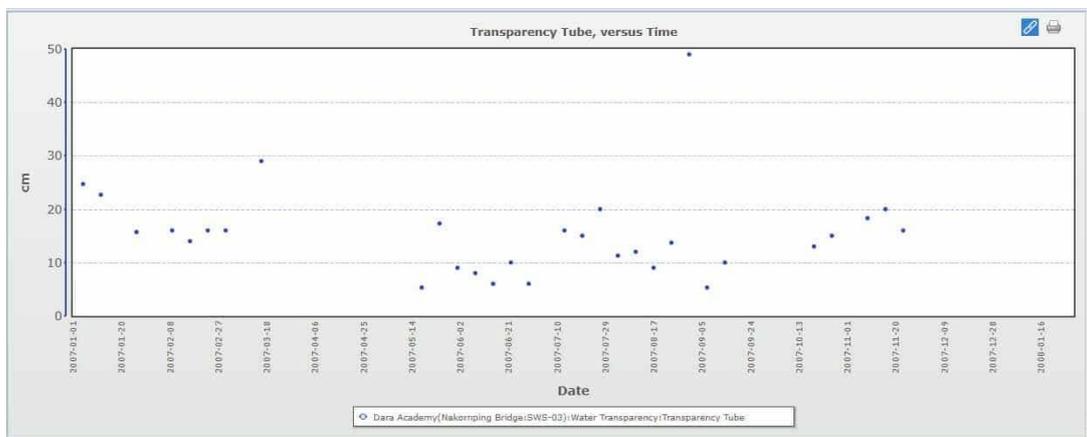
4.4 Changes in Water Transparency

Water transparency, which serves as an indicator of suspended sediments and turbidity, showed a decreasing trend during the early and middle parts of the year, particularly in May when values reached a minimum of approximately 5 centimeters. Transparency subsequently increased markedly in September, possibly as a result of reduced sediment loads following the rainy season. These variations reflect the influence of soil erosion from agricultural areas and urban construction zones, as well as surface runoff that transports suspended materials into the Ping River.

4.5 Water Quality Index (WQI)

The assessment of the Water Quality Index, which integrates physical, chemical, and biological parameters, revealed that in the upper reaches of the Ping River the index values tended to decline from fair conditions at the beginning of the study period to degraded levels in certain years. Although slight signs of recovery were observed in later years, overall water quality has not yet returned to acceptable standards. The WQI values indicate elevated levels

of organic contamination, coliform bacteria, and ammonia, all of which adversely affect aquatic organisms and the overall environmental condition of the Ping River.

The results demonstrate that the water quality of the Ping River in Chiang Mai Province has changed markedly on both seasonal and long-term scales. Electrical conductivity and water transparency exhibited trends that reflect pressures from human activities, whereas dissolved oxygen and water temperature were closely associated with climatic conditions. When the Water Quality Index is considered collectively, the overall status of the river in certain areas shows a tendency toward degradation, underscoring the necessity for continuous and systematic water-quality monitoring. These findings therefore provide an important foundation for the in-depth discussion in the following chapter regarding the causes of change and approaches for sustainable water-resource management

These data serve as an important database for in-depth discussion in the following chapter regarding the causes of water quality changes and approaches to sustainable water resource management.
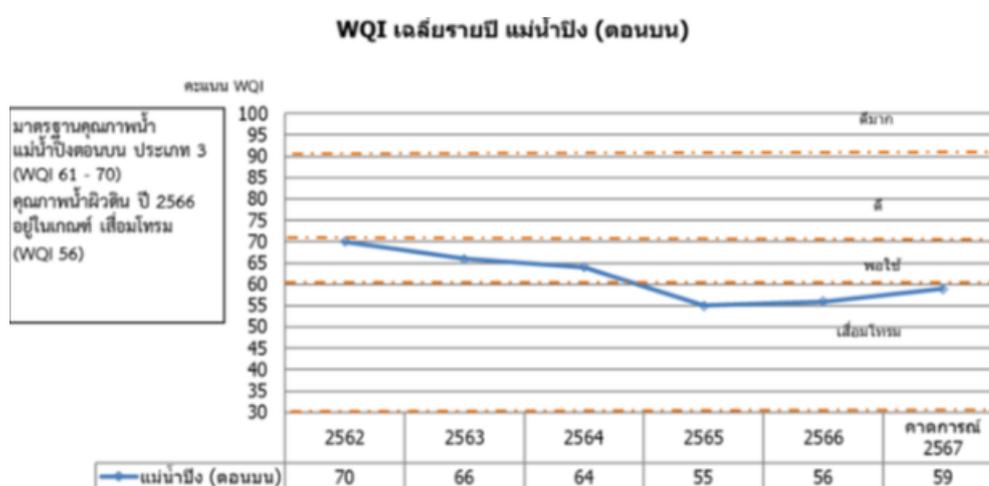
Supporting data: 2019–2023

สถานี	ที่ตั้ง	คุณภาพน้ำที่สำคัญ					(WQI)	เทียบได้กับมาตรฐานแหล่งน้ำผิวดินประเภท (เกณฑ์คุณภาพน้ำ)	ปัญหาคุณภาพน้ำผิวดินที่สำคัญ
		DO (mg/L)	BOD (mg/L)	TCB (MPN/100ml)	FCB (MPN/100ml)	NH_3 (mg/L)			
PI10	สะพานหน้าศูนย์อุทกวิทยากองหิน ต.หางดง อ.ฮอด จ.เชียงใหม่	7.17	1.42	9,733	1,110	1.06	59	ประเภทที่ 4 (เสื่อมโทรม)	NH_3
PI11	สะพานหนองปลาสวาย–ดงหาดนาค ต.สบเตี๊ยะ อ.จอมทอง จ.เชียงใหม่	8.75	1.15	4,233	158	0.66	62	ประเภทที่ 3 (พอใช้)	NH_3
PI11.1	สะพานป่าแดด-ท่าวังตาล ต.ป่าแดด อ.เมือง จ.เชียงใหม่	5.45	3.00	76,667	33,400	2.32	39	ประเภทที่ 4 (เสื่อมโทรม)	BOD TCB FCB NH_3
PI12	สะพานมหิดลข้าง สถำรวจภูธรภาค 5 ต.หนองหอย อ.เมือง จ.เชียงใหม่	5.83	1.40	16,333	2,693	1.19	54	ประเภทที่ 4 (เสื่อมโทรม)	NH_3
PI13	สะพานป่าตัน บ้านวังสิงห์คำ ต.ป่าตัน อ.เมือง จ.เชียงใหม่	5.56	1.91	13,733	433	2.86	47	ประเภทที่ 4 (เสื่อมโทรม)	NH_3
PI14	สะพานช่อแล บ.ช่อแล ต.ช่อแล อ.แม่แตง จ.เชียงใหม่	6.72	1.95	13,733	520	1.87	50	ประเภทที่ 4 (เสื่อมโทรม)	NH_3

Upper Ping River Water Quality

Water quality in the upper Ping River (PI10–PI14) has significantly deteriorated, with WQI values ranging from 39 to 62. High Biochemical Oxygen Demand (BOD) levels (3.00 mg/L) and

severe bacterial contamination (Total Coliform Bacteria: 76,667 MPN) at station PI11.1 indicate serious pollution from untreated wastewater and animal waste.

In addition, excessive ammonia levels at all stations, caused by the decomposition of organic matter and surface runoff, pose a serious threat to the aquatic ecosystem. Urgent waste management measures are needed to prevent further environmental degradation

WQI เฉลี่ยรายปี แม่น้ำปิง (ตอนบน)

	2562	2563	2564	2565	2566	คาดการณ์ 2567
แม่น้ำปิง (ตอนบน)	70	66	64	55	56	59

Water Quality Classification Based on WQI

The graph shows water quality levels based on the Water Quality Index (WQI) as follows

80 points and above: Very good / Good water quality

61–70 points: Fair water quality (meets the target standard)

31–60 points: Degraded water quality

Comparison of Water Quality

The comparison of water quality between the year 2007 and the period from 2019 to 2023 shows a clear decline in river health. Both chemical and biological data indicate that the river ecosystem is deteriorating due to increased human activities and technological development. As urban areas expand, chemical pollutants in the water increase, while biodiversity decreases, leaving only pollution-tolerant organisms.

To solve this problem, stricter wastewater control measures and law enforcement are needed, along with the use of real-time water quality monitoring technology. In addition, raising public awareness is important to ensure that development does not occur at the cost of destroying water resources that are essential for long-term sustainability.

Chapter 5

Discussion and Recommendations

5.1 Discussion

The comparative analysis of long-term trends in the physicochemical water quality of the Ping River in Chiang Mai Province demonstrates that water quality has changed significantly on both seasonal and spatial scales. The most pronounced changes were observed in the middle reaches of the river, which are characterized by dense urban communities, where electrical conductivity increased and water transparency declined continuously. These patterns reflect the influence of urban expansion and human activities along the river corridor and are consistent with the second research hypothesis.

With respect to dissolved oxygen, declining trends were observed during certain periods of the year, particularly during the rainy season and late summer. These reductions may be attributed to higher water temperatures and increased organic matter inputs from municipal wastewater and agricultural activities, supporting the first research hypothesis that identifies DO as a key indicator of pollution levels in aquatic systems.

When the Water Quality Index (WQI) was considered together with biological and chemical data, the overall condition of the Ping River during certain periods was found to have deteriorated from fair to below-standard levels. This trend was especially evident at several upstream monitoring sites where elevated concentrations of coliform bacteria and ammonia were detected. These findings are consistent with the report by Rungruangwong (2023), which emphasizes the importance of effective community wastewater treatment systems in reducing impacts on natural water bodies.

Furthermore, comparisons between data collected in 2007 and those from the period 2019–2023 reveal an overall declining trend in water quality across physical, chemical, and biological parameters. This deterioration may be associated with increasing population density, changing land-use patterns, and continued urban infrastructure development. Without the implementation of concrete mitigation and restoration measures, such pressures could lead to long-term degradation of riverine ecosystems.

In summary, this study analyzed long-term trends in the physicochemical water quality of the Ping River in Chiang Mai Province by comparing monitoring data from 2007 with records from 2019–2023 collected under the standardized protocols of the GLOBE Program. The

principal parameters examined included water temperature, electrical conductivity, water transparency, dissolved oxygen, and the Water Quality Index (WQI). The findings provide deeper

Insight into the combined influences of natural seasonal variability and human activities on the overall condition of the Ping River system. With respect to the research questions, the analysis indicates that dissolved oxygen and electrical conductivity are particularly sensitive indicators of water-quality change, especially in urbanized sections of the river. Moreover, the long-term increase in conductivity together with declining transparency supports the hypothesis that urban expansion, land-use change, and population growth have contributed to pressures on the river ecosystem.

These pressures have continuously affected the Ping River ecosystem. The overall trend analysis between the two study periods revealed a gradual deterioration in water quality, particularly in several upstream and middle sections of the river where the Water Quality Index declined below target standards. Although slight signs of recovery were observed in the most recent years, many areas of the river remain classified as degraded, underscoring the urgent need for sustained restoration efforts and continuous control of pollution sources.

The outcomes of this study can serve as an important baseline for watershed management and environmental planning in northern Thailand. Identifying river segments that are vulnerable to pollution can assist relevant agencies in prioritizing improvements to wastewater treatment systems, regulating pollutant discharges, and restoring riparian zones. The findings also emphasize the importance of continuous water-quality monitoring in detecting emerging trends and evaluating the effectiveness of management interventions.

Importantly, this research highlights the value of the GLOBE Program as a platform that links student-led field observations with global environmental databases through the use of standardized methodologies and GLOBE data visualization tools. These approaches ensure systematic comparisons across time periods and locations while fostering scientific inquiry skills and environmental stewardship among students. Continued participation in the GLOBE network will strengthen regional water-quality surveillance and support collaborative efforts to protect the Ping River for Chiang Mai Province and for future generations.

5.2 Recommendations

ased on the findings of this study, the research team proposes the following recommendations to support the sustainable management and conservation of the water quality of the Ping River.

5.2.1 Environmental Management Recommendations

1. The efficiency of municipal and industrial wastewater treatment systems in urban areas should be enhanced, and the discharge of effluents from pollution sources should be strictly regulated.

2. The establishment of continuous water-quality surveillance systems (real-time monitoring) at key locations along the river should be promoted in order to enable timely detection of environmental changes.

3. The restoration of riparian areas—such as planting vegetation along riverbanks and conserving natural wetlands—should be supported, as these measures can reduce sediment erosion and the transport of excess nutrients into the river.

4. Community and educational institution participation in water-quality monitoring under the GLOBE Program should be encouraged to foster long-term awareness and stewardship of water reso

5.2.2 Recommendations for Future Research

1. The duration of data collection should be extended and the number of monitoring sites increased to encompass the entire river system, thereby enabling clearer identification of watershed-scale trends.

2. Additional biological parameters—such as the diversity of benthic macroinvertebrates or plankton communities—should be investigated as indicators of ecosystem health.

3. Statistical models should be applied to analyze relationships among human activities, land-use patterns, and water quality in order to project future trends and support evidence-based policy planning.

Chapter 6

GLOBE (Badge Descriptions)

This chapter describes the roles and learning processes of the research team according to the evaluation criteria of the GLOBE Virtual Science Symposium. It reflects the actual activities carried out by the students throughout the research process, from planning field data collection and conducting statistical analyses to interpreting results, communicating findings, and generating positive impacts on the community and the environment.

In the role of Data Scientists, the research team collected water quality data from field measurements following GLOBE protocols, together with information from meteorological stations and long-term environmental databases. All datasets were organized and managed using digital tools such as Google Sheets and the GLOBE data visualization platform to ensure accuracy and completeness prior to analysis. The team examined temporal trends, compared conditions between the year 2007 and the period 2019–2023, and produced graphs and interpretations of changes in key parameters such as dissolved oxygen, electrical conductivity, and water transparency. These processes strengthened skills in data management, analytical thinking, and the use of empirical evidence to address the research questions.

In the role of Earth System Scientists, the research team investigated linkages among components of the Earth system that influence water quality in the Ping River, including topography, climate, land use, and human activities. Using Google Earth and field surveys, the team characterized environmental conditions at each monitoring site and compared upstream, midstream, and urban sections to understand how natural and anthropogenic factors interact to shape water quality patterns. This integrative analysis fostered systems-level understanding of the interactions among atmospheric processes, the land surface, and human activities within the river system.

The research team used the study results to communicate water quality issues to teachers, students, and local communities through presentations, school exhibitions, and dissemination of academic information in order to raise awareness of the declining trends in the Ping River and the importance of water resource conservation. Furthermore, the findings were incorporated into environmental education and long-term water quality monitoring within the GLOBE framework, representing meaningful educational and community-level impacts without

overstating outcomes. These activities also encouraged youth participation in sustainable natural resource stewardship for future generations.

References

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I AM A DATA SCIENTIST

Data source: Analyze data in depth using real data collected by the research team. Combined with historical data from the GLOBE database to compare the quality of Ping water in the long term.

Analysis: Use conductivity data and transparency to analyze trends (Trends) and answer research questions on how urban expansion affects water quality.

Inferences and limitations: Bring data to predict future events to monitor pollution. Ready to discuss the limitations of the data so that the research results are reliable and can be used to solve practical problems in the ecosystem

I AM AN EARTH SYSTEM SCIENTIST

The interconnectedness of the earth system (Interconnectedness): Research shows that activities in the "Anthroposphere" (Anthroposphere) such as urban expansion Directly affect the water quality in the "hydrosphere" (Hydrosphere) by reflecting through changing physical chemistry values.

Use of GLOBE methodology (GLOBE Protocols): Use GLOBE benchmarks to collect data and analyze the relationship between physical factors (such as transparency) and chemistry (such as conductivity) to explain the dynamics of the Ping water system.

Systematic interpretation: Analyze data to explain how processes in a system affect and depend on each other in order to understand the health of the river as part of the ever-changing world system

I MAKE AN IMPACT

Problem to question: Using real data to prove that the expansion of Chiang Mai results in higher conductivity and reduced transparency in the long term or not to monitor the health of the Ping River.

Local to the world: Maintaining the Ping River helps reduce pollution that will flow into the ocean (Source to Sea) in line with the Global Sustainability Goals (SDGs).

Practice: Create a volunteer network in the community and propose to the state to control wastewater discharge during the "dry season crisis" to maintain a sustainable ecosystem