應用主成分分析於量化水庫優養化與監測水質之關聯性

Application of Principal Component Analysis to Quantify the Relationship Between Reservoir Eutrophication and Water Quality Monitoring

國立臺灣大學生物環境系統工程學系

碩士生	副教授	博士生
吳鈺婷	江莉琦	盧至美
Yu-Ting Wu	Li-Chi Chiang	Chih-Mei Lu

摘　要

水庫優養化為攸關水資源利用之重大議題，通常發生於集水區或水體上游人為活動增加，導致大量營養鹽如氮、磷等透過地表逕流、側向流等方式流入水庫中。根據環保署 111 年度水庫水質監測資料，台灣有 20 座主要水庫屬優養程度。本研究旨在分析四大優養化水庫(明德、白河、澄清湖、鳳山)，探討每個水庫中影響水質的主要因素和汙染源。本研究利用主成分分析(Principal Component Analysis, PCA)方法對不同水庫的水質數據進行了深入研究。PCA 是一種常用的多變量數據分析方法，用於降低數據維度、發現數據中的模式和結構，其主要目的為通過將原始變數轉換為新的一組互相無關的主成分因子，捕捉數據庫中變異性最大處，並將主成分因此依其變異大小排序，以了解主成分因子與水質的相互關係。為此，本研究蒐集四大優養化水庫之水質監測數據: 溶氧、氨氮、硝酸鹽氮、氨氮、總磷等多個水質檢測項目，執行各個水庫之 PCA，通過將水質檢測項目轉換為主成分因此，以識別影響各個水庫優養化的主因。透過 PCA 的分析結果，研究發現每個水庫的主要影響因素和模式存在差異，反映了在不同集水區下水庫集水區受到不同污染源和環境影響。這些發現有助於更全面地了解每個水庫的水質特性，並為未來針對性的水質管理和保護措施提供寶貴的參考依據。未來深入探討水質問題背後的機制，並提出有效的解決方案，以促進水資源的可持續利用和保護。

關鍵詞: 水庫優養化、水質分析、主成分分析

Abstract

Eutrophication of reservoirs is a major issue concerning the utilization of water resources, typically occurring due to increased human activities in the catchment area or upstream of the water body. These activities lead to the influx of large amounts of nutrients, such as nitrogen and phosphorus, into reservoirs through surface runoff and lateral flow. According to the Environmental Protection Administration's 2022 reservoir water quality monitoring data, 20 major reservoirs in Taiwan are classified as eutrophic.

This study aims to analyze the four major eutrophic reservoirs—Mingde, Baihe, Chengqing Lake, and Fengshan—to investigate the main factors affecting water quality and sources of pollution in each reservoir. The study utilizes Principal Component Analysis (PCA) to conduct an in-depth examination of the water quality data from different reservoirs. PCA is a widely used multivariate data analysis method for reducing data dimensions and identifying patterns and structures within the data. The main purpose is to transform the original variables into a new set of uncorrelated principal components, capturing the maximum variability in the dataset. These principal components are then ranked by the magnitude of their variance to understand the relationship between principal components and water quality.

These findings contribute to a more comprehensive understanding of the water quality characteristics of each reservoir and provide valuable references for future targeted water quality management and protection measures. Future research will delve deeper into the mechanisms behind water quality issues and propose effective solutions to promote sustainable utilization and protection of water resources.

Keywords: Eutrophication of Reservoirs, Water Quality Analysis, Principal Component Analysis (PCA)