



ISSN (p) 2411-7161

ISSN (e) 2712-9500

№ 7/2026

НАУЧНЫЙ ЖУРНАЛ «IN SITU»

Москва
2026

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ASSESSING SURFACE WATER QUALITY IN THE MAIN RIVERS OF MINING DISTRICTS IN LAO CAI PROVINCE USING CLUSTER ANALYSIS (CA) AND PRINCIPAL COMPONENT ANALYSIS (PCA)

This study applied Cluster Analysis (CA) and Principal Component Analysis (PCA) to assess and classify the surface water quality of rivers and streams flowing through copper, gold, and apatite mining and processing areas in Lao Cai Province, Vietnam. Eight rivers and streams were investigated, including Chan Stream, Nam Xay Stream, Ngoi Duong Stream, Dong Ho Stream, Chu O Stream, Ngoi Phat Stream, the Red River, and Khe Chom Stream. The CA and PCA results classified the monitoring sites into three distinct groups. Group 1 (Chan and Nam Xay Streams) was characterized by elevated concentrations of Cu, TSS, BOD₅, and COD. Group 2 (Chu O, Dong Ho, Red River, Ngoi Duong, and Ngoi Phat) represented watersheds heavily impacted by copper and apatite mining, dominated by high TSS and Cu. Group 3 (Khe Chom Stream) was distinguished by high nutrient levels Fe , PO_4^{3-} , NH_4^+ , NO_2^- . The findings indicate that surface water in mining areas is predominantly affected by excavation dust (TSS), whereas ore processing zones are influenced by chemical processing components (PO_4^{3-}).

Keywords:

Surface water quality; Cluster Analysis (CA); Principal Component Analysis (PCA); Mining-impacted watersheds; Heavy metals; Lao Cai Province.

Introduction

Mining and mineral processing are among the major industrial activities in Lao Cai Province, Vietnam. While these activities make significant contributions to regional economic development, they also pose potential risks to the quality of surface water in rivers and streams located within or adjacent to mining and mineral processing areas. The discharge of mine wastewater, the transport of suspended solids, and the release of heavy metals may adversely affect the aquatic environment.

Materials and Methods

Study Area and Data Collection

The study focused on assessing the surface water quality of rivers and streams flowing through major mining and mineral processing areas in Lao Cai Province, northern Vietnam. The selected monitoring locations include Khe Chom Stream, Ngoi Duong Stream, Dong Ho Stream, Chu O Stream, the Red River, Ngoi Phat Stream, Chan Stream, and Nam Xay Stream.

Statistical Characteristics of Surface Water Quality

Surface water quality data were obtained from the Lao Cai Environmental Monitoring Center, spanning a six-year period from 2017 to 2022. A summary of the descriptive statistics for all monitored parameters is presented in Table 1.

Table 1

Descriptive statistics of surface water quality parameters (2017–2022).

River	Parameters	COD	BOD ₅	TSS	Cu	Fe	NH ₄ ⁺	NO ₂ ⁻	PO ₄ ³⁻
Chan	Mean (mg/l)	26.6	11.2	32.8	0.052	0.616	0.279	0.040	0.074
	Min (mg/l)	8.3	4.0	3.4	0.006	0.087	0.040	0.003	0.004
	Max (mg/l)	60.5	24.4	202.3	0.220	1.310	0.894	0.137	0.260
Khe Chom	Mean (mg/l)	27.0	11.0	40.2	0.043	1.656	2.185	0.468	1.577
	Min (mg/l)	4.4	2.1	12.2	0.006	0.106	0.136	0.062	0.007
	Max (mg/l)	58.6	26.7	158.3	0.133	8.560	12.40	1.230	6.330
Nam Xay	Mean (mg/l)	23.6	10.1	26.0	0.043	0.609	0.221	0.031	0.095