Research article

Some Physico-Chemical Characteristics of Surface Water in Mining Areas in the Lao PDR

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Abstract Lao People's Democratic Republic (the Lao PDR), is naturally enriched with mineral resources having been the important potential in the country socio-economic development. Mining activities for utilizing such resource is expected to bring not only benefit but also environmental problems such as deforestation due to land opening, surface water quality decline. The objective of this study was to initially investigate the surface water quality of the two main rivers (Namkok and NamMo) near two mining areas (Sepon and PhuBia) in Savannakhet and Xaysomboun provinces, respectively. Water samples from 5 sampling sites on each river were analyzed for physical (pH, EC, temperature, turbidity, TDS,) and chemical (alkalinity, DO, COD, inorganic cations and anions, and some heavy metals) characteristics in two sampling times (May and July) in 2021. The finding results unveiled that the water of the two rivers had temperature of 23-32^{o}C, DO 8-16 mg/L and COD 1.8-64 mg/L. The water pH, EC, and alkalinity were found at values of 7-8, 83-576 µS/cm, and 48-174 mg-$CaCO_3$/L ranges, respectively. In contrast, the amount of TDS in the both rivers were 53-369 mg/L. The detected dominant cations were Na^+, Ca^{2+} and Mg^{2+} and their concentration was in a concentration range of 0.5-34 mg/L, while main anions were F^-, Cl^- and SO_4^{2-} (3-9 mg/L). The particulate matter content in the water in the form of TSS (67-372 mg/L) were observed. The presence of both TDS and TSS might lead to the water turbidity of as low as 5 NTU or as high as 200 NTU. The investigated heavy metal concentration was typically low. Based on the findings, the water quality of the two rivers at the time of investigation was not beyond the Lao national environmental quality criteria.

Keywords physico-chemical characteristics, surface water, mining areas, the Lao PDR

INTRODUCTION

Lao People's Democratic Republic (Lao PDR or Laos), a country in Indochina peninsula, has an outstanding abundance of natural resources such as densely forest for reserving the water resources and its quality, nutrient-rich abundance for agriculture, streams for agricultural irrigation, human-being livelihood and water resources for hydropower development, precious minerals, charm and beautiful tourist sites (Kiprop, 2019). If well managed and used, the natural resources wealth contribute to the national development and bring benefit to Lao people (Vostroknutova, 2010). Depositing in many parts of Laos, it has identified that more than 570 mining areas where gold, copper, zinc and lead covered around 47%, which are the socio-economic development potentials of Laos (Kyophilvong, 2009). Two main mining companies in Laos are Lanxang Mineral Company which have been operating at Vilabuly district of Savannakhet province since 1993, and PhuBia Mining Company Limited which have been operating at Anuvong district of Xaysomboun province since 1994 (Shibata, 2008).

The environmental impacts from mining is diverse, and various tools are needed for monitoring and assessing the impacts (Islam et al., 2020). Physical, biological and chemical properties are the main components of water quality for assessing the mining caused impacts to the water sources environment (Amin et al., 2016; Hirwa et al., 2019). The water quality assessment could provide important information for protecting environment and people living downstream of the mining areas (Gerhardt et al., 2004). However, the mostly concerned river water pollution caused by mining is the presence of heavy metals of which their concentration and distribution in the surface water are dominated by the geochemical situation and the pollution source, but seriously affected by mining leachate and chemical wastewater discharge (Liang et al., 2011). Therefore, the inspection of mining companies which must follow the environmental standard criteria and the participation of the publics in the water quality monitoring (WQM) might have challenges beyond the environmental responsibility of the authorities: (1) scientific soundness, (2) political relevance and (3) harmonization in WQM implementation (Mercado-Garcia et al., 2019).

OBJECTIVE

The objective of this study was to investigate the physico-chemical characteristics of the main rivers – NamKok and NamMo rivers near the two gold-copper mining areas in Vilabuly and Anuvong districts of Savannakhet and Xaysomboun provinces, respectively.

METHODOLOGY

Sampling Sites and Times

The physico-chemical characteristics of NamKok and NamMo were investigated in two sampling times – one in May and another in July as a representative of dry and rainy season in 2021. The typical maps of the two mining areas where 5 selected sampling sites were marked are shown in Fig. 1. The selected sampling sites are the same places where the water quality was also monitored by the companies' environmental monitoring units.

Sampling and Analytical Method

The water samples collected by grabbing method were either preserved or non-reserved and stored in plastic sample bottles according to the parameters - alkalinity, hardness, chemical oxygen demand (COD), inorganic cations and anions, and heavy metals for being analyzed in a laboratory. During transportation to the laboratory, the all sample in the bottles were kept in an ice box with cooling packs. The electrical conductivity (EC), pH, dissolved oxygen (DO), temperature and turbidity of water samples was measured at the sampling sites using portable multi-parameter water quality meter and turbidity meter. Total dissolved solids (TDS) was estimated from EC, while total suspended solid (TSS) was determined by Standard Methods 2540 D (dried at 103-105°C), alkalinity, hardness by titrimetric method, COD by potassium dichromate method, inorganic cations and anions by ion chromatographic method, heavy metals (Cu, Pb, Cr, As, Hg, Zn, Cd, Ni, Fe) by atomic absorption spectrometric method (APHA et al., 2017).

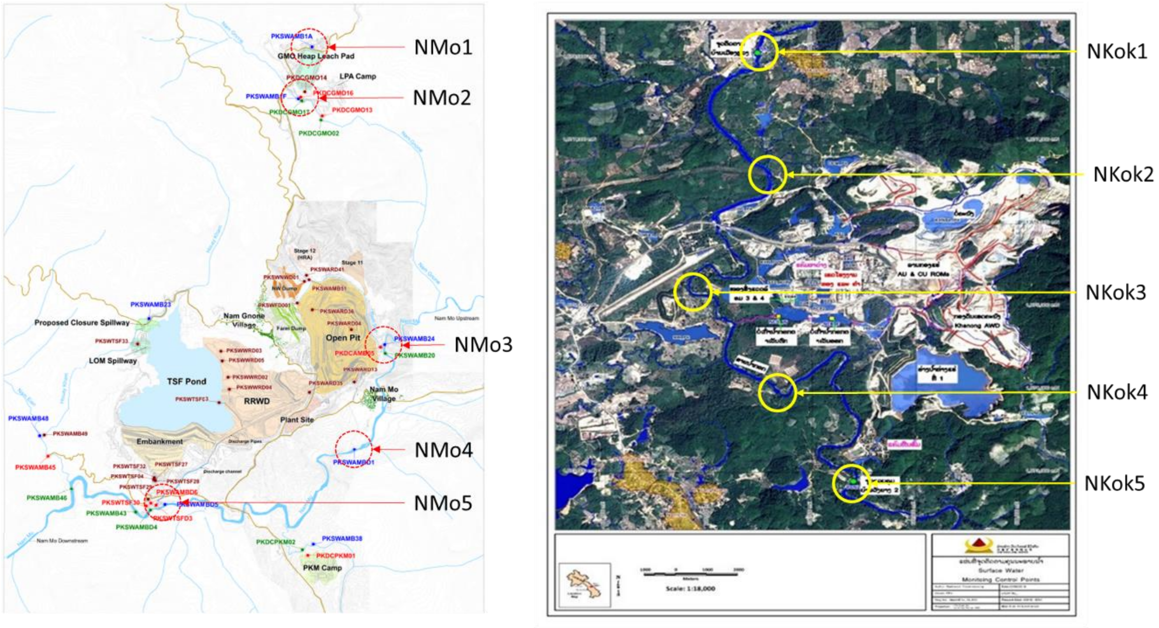

Fig. 1 A typical topographic maps of 5 sampling sites in NamMo (NMo1-5) and NamKok (NKok1-5) in PhuBia and Sepon Mining Areas

RESULTS AND DISCUSSION

Temperature, pH, DO and Alkalinity

The comparison of temperature, pH, DO and Alkalinity for the two rivers (NamMo and NamKok) are shown in Fig. 2. The temperature and pH characteristics of them were similar. In contrast, NamKok's DO and alkalinity was somehow higher than those of NamMo. The difference in the river's alkalinity in May and July would be due to their seasonal hydrological and geographical characteristics. High alkalinity of these rivers would be good for high buffering capacity of the water against change in pH (Weiner and Matthews, 2003), and this would be correlated to the observed pH.

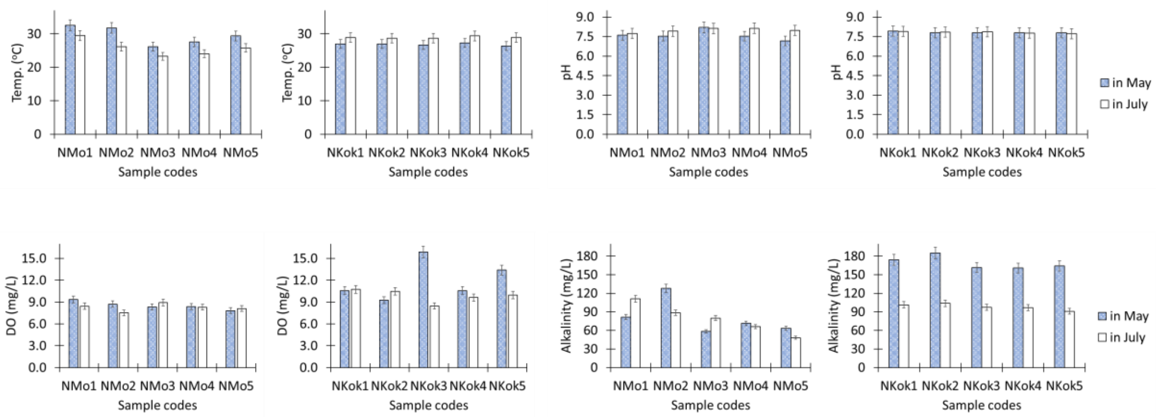

Fig. 2 Temperature, pH, DO and Alkalinity of NamMo (NMo1-5) and NamKok (NKok1-5) in May and July 2021

TDS, TSS, EC, Turbidity and COD

The analytical results of the two rivers in terms of TDS, TSS, EC, turbidity and COD are shown in Fig. 3. NamKok river showed its TDS and TSS characteristics higher than that of NamMo in May, but not much different in July, and this would lead to their similar properties on EC. For COD, both rivers showed high values in opposite month, the reason is still unclear whether by the effect of water nature dilution or anthropogenic mining activities (Xu et al., 2020).

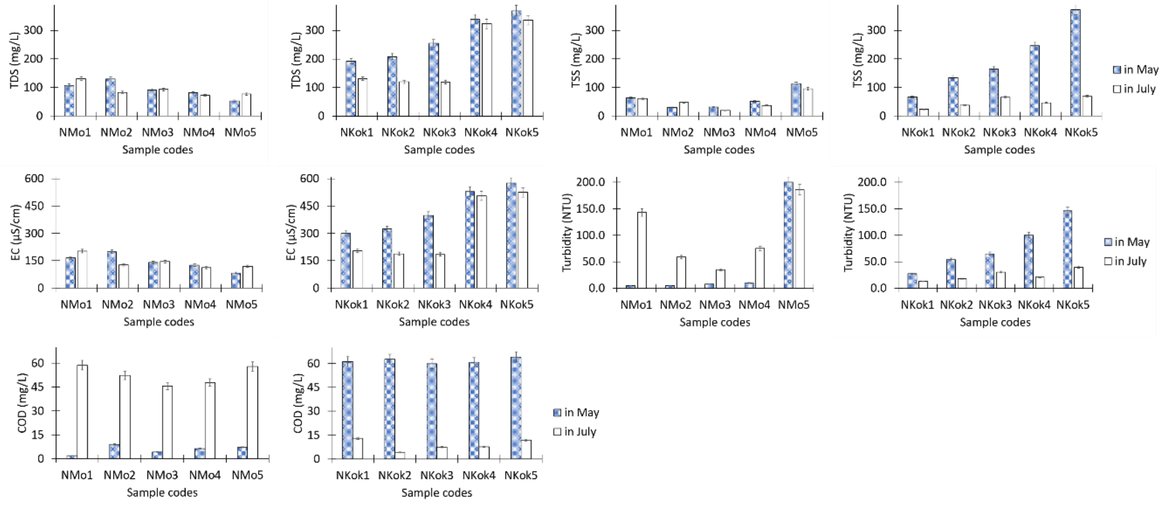

Fig. 3 TDS, TSS, EC, Turbidity and COD of NamMo (NMo1-5) and NamKok (NKok1-5) in May and July 2021

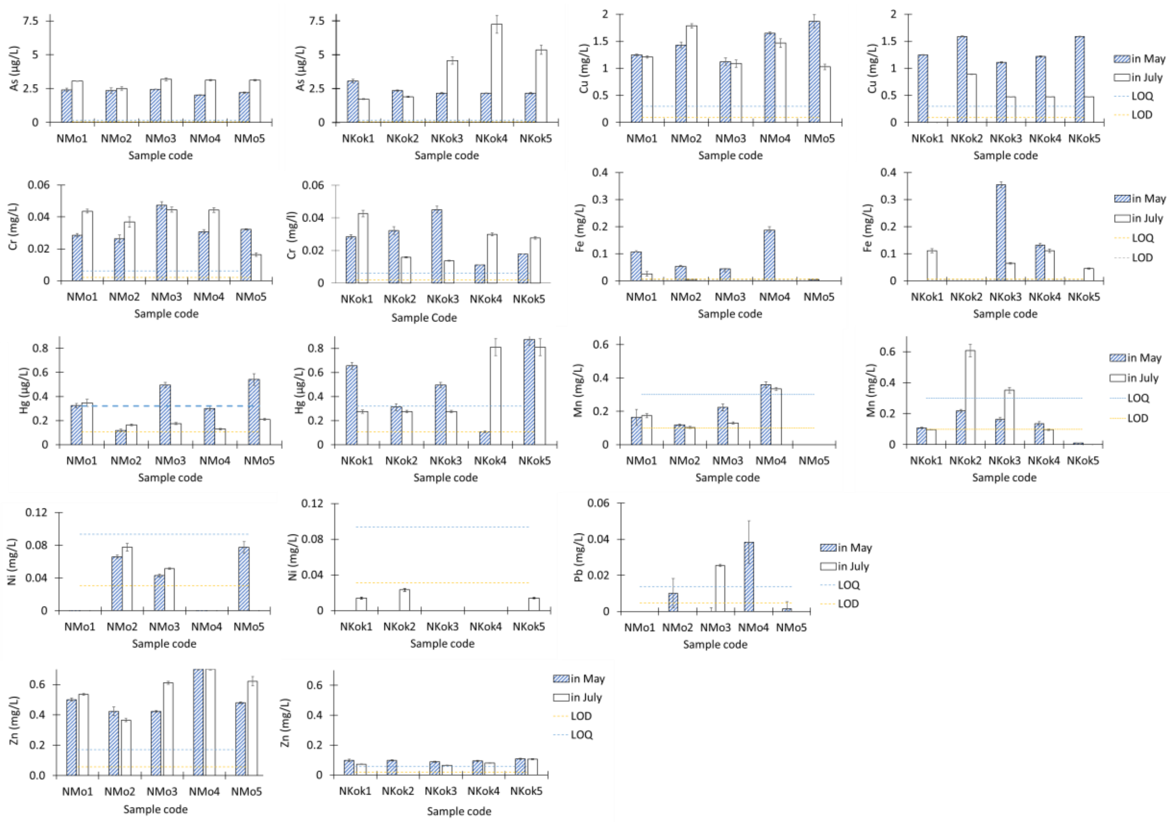

Fig. 4 Characteristics of Some heavy metals in NamMo (NMo1-5) and NamKok (NKok1-5) in May and July 2021

Characteristics of Some Heavy Metals in NamMo and NamKok

The contamination of heavy metals in water resources nearby the mining operation activities is the most concerned as most of heavy metals are toxic even at very low concentration (Fashola et al., 2016; Liang et al., 2011; Mahato et al., 2017). In this study, the presence of less toxic metals (Fe, Cu, Zn) and much toxic metals (As, Cr, Cd, Ni, Pb, Hg) in NamMo and NamKok rivers were investigated and the results are shown in Fig. 4.

The concentrations of heavy metals in NamKok river were mainly higher than those in NamMo, except Zn and Ni. The Zn concentration in NamMo river was much higher than that in NamKok and it is expected that Zn metal might be abundant in nature nearby the NamMo area. Concerning As, its concentration in NamMo river was found similar in all 5 sampling sites indicating that such presentation would occur naturally (Wurl et al., 2018).

In contrast, the presence of As in NamKok river in July in downstream was somehow higher than those in upstream, indicating that leaching As from upstream area due to runoff would be expected as the cause (Dai et al., 2013). Similarly, the concentration of Hg in water sampled at the down-stream in both rivers was higher than those at upstream. The presence of Hg in the surface water could occur through soil erosion, surface runoff, and land use in the mining areas (Dai et al., 2013). The presence of Cr in both NamMo and NamKok rivers is in similar characteristics, while the highest concentration of Cr peaked at the middle stream. Furthermore, the presence of Cr in such concentration in both rivers would be due to its natural occurrence (Chrysochoou et al., 2016; Ferronato and Torretta, 2019; Mani Tripathi and Chaurasia, 2020). The presence of Ni in both rivers was very low indicated by its concentration below the detection limit.

CONCLUSION

This study unveiled, even not completely, that the water quality of the two rivers - NamMo and NamKok in the mining operation areas at the time of our investigation is still not in serious situation according to their physico-chemical characteristics which were not beyond the limited value in comparison to the Lao national environmental standard (2017) on surface water quality. The water quality of the two rivers would be affected by the seasonal (May versus July) and geographical (upstream versus downstream) difference. The results from this study could be used as a fundamental scientific data for further study. However, it is recommended that more sampling frequency and sites should be further taken into account for future investigation so that the water characteristics would be more realistic.

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