Assessment of Sedimentation Pond Seepage at Akara Mine, Phichit Province Using Electrical Resistivity Tomography and Hydrochemical Analysis

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ABSTRACT

This study assessed potential seepage from Sedimentation Pond 12 at the Akara Mine, Phichit province, to surrounding water resources using electrical resistivity tomography (ERT) and hydrochemical analysis. The ERT survey employed a dipole–dipole configuration with 1.5 m electrode spacing along a 330 m profile. The resulting two-dimensional resistivity section was interpreted together with borehole lithology and hydraulic head data. Groundwater flow direction coupled with an interpreted hydrogeologic cross section were analyzed to verify hydraulic connectivity between the pond and the shallow aquifer. The results suggest that the shallow groundwater system and Sedimentation Pond 12 are linked to the same unconfined aquifer. The subsurface was interpreted as three hydrostratigraphic units: (1) an upper lateritic layer (5 m thick) forming the shallow unconfined aquifer and hydraulically connected to the pond; (2) an intermediate clay and weathered rock (15 m thick) acting as an aquitard; and (3) underlying bedrock associated with a deeper confined aquifer. Hydrochemical analysis was based on 21 surface water samples, 16 shallow groundwater samples (unconfined aquifer), and 16 deep groundwater samples (confined aquifer). Physical and chemical properties were measured, and hydrochemical facies were identified using Piper and Stiff diagrams. Dominant geochemical controls on water chemistry were evaluated using Gibbs diagram. Surface water exhibited pH of 5.62–8.98, electrical conductivity (EC) of 100–4,900 µS/cm, and total dissolved solids (TDS) of 50–2,450 mg/L, with a dominant calcium–sulfate ($Ca–SO_4$) water type. Shallow groundwater showed pH of 5.04–6.52, EC of 30.4–1,255 µS/cm, and TDS of 15.3–627.3 mg/L, and was predominantly characterized by a calcium–bicarbonate ($Ca–HCO_3$) water type, with one downgradient well exhibiting a $Ca–SO_4$ type. Deep groundwater exhibited pH of 6.06–6.76, EC of 154.8–502.1 µS/cm, and TDS of 77.4–334.0 mg/L, and was characterized by a $Ca–HCO_3$ water type. Gibbs plots suggests that surface water and shallow groundwater chemistry are primarily influenced by rainfall recharge, runoff, and mining-related inputs, whereas deep groundwater chemistry is mainly controlled by water–rock interaction. Given the lateral continuity of hydrogeologic units and the hydraulic connection between the pond and the lateritic unconfined aquifer, shallow groundwater is the most likely receptor if seepage occurs. Overall, the results suggest a plausible seepage pathway from the pond to the shallow unconfined aquifer, with potential risk to nearby agricultural areas. Therefore, continuous groundwater monitoring is recommended to manage potential long-term environmental impacts.

STUDY AREA

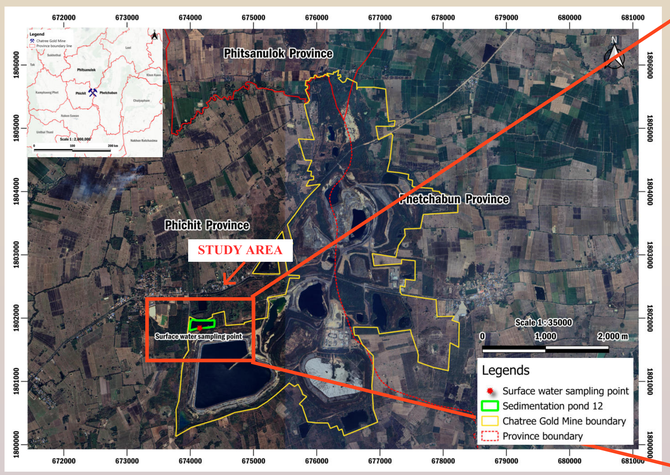


Fig 1. The Chatree Gold Mine or Akara Mine is located in Khao Chet Luk Subdistrict, Thap Khlo District, Phichit Province, central Thailand, near the boundary of Phichit, Phetchabun, and Phitsanulok provinces.

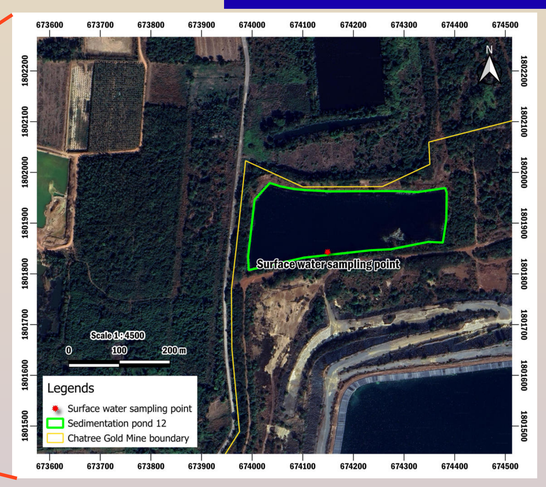


Fig 2. The study area focuses on Sedimentation Pond 12 and surrounding area, located in the southwestern sector of the Chatree Gold Mine.

OBJECTIVES

To investigate potential seepage from the sedimentation pond and it's migration into the surrounding agricultural areas using Electrical Resistivity Tomography (ERT) and hydrochemical analysis.

METHODOLOGY

Electrical Resistivity Tomography

- Dipole-dipole configuration
- Survey line length : 330 m
- Electrode spacing : 1.5 m

Cross-sectional profile 2D model

Hydrochemical Analysis

- Water sampling
  > 21 Surface water samples
  > 32 Ground water samples

Physical and chemical properties analysis
> pH, TDS, EC (field measurement)
>Cations : Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}
>Anions : HCO_3^{-}, CO_3^{2-}, Cl^{-},SO_4^{2-}
>Heavy Metals : Fe^{2+}, Mn^{2+}

Data interpretation and visualization : Piper, Gibbs and Stiff Diagrams

CONCLUSIONS

- Results from ERT and hydrochemical facies analysis suggest that the unconfined aquifer exhibits lateral continuity and is hydraulically connected to Sedimentation Pond 12 as well as nearby surface water bodies. However, no hydraulic connection with the deeper confined aquifer was identified.
- If contamination occurs in Sedimentation Pond 12, the shallow groundwater with in the unconfined aquifer may also be affected. Continuous monitoring of the unconfined aquifer is recommended to manage potential risks and mitigate possible environmental impacts on the surrounding area.

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RESULTS

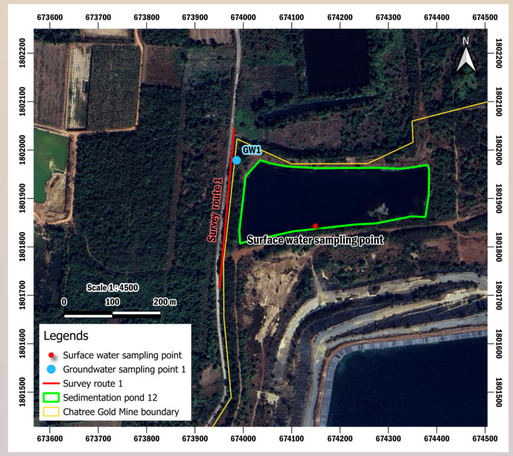


Fig 3. Electrical Resistivity Tomography (ERT) survey line along the western side of Sedimentation Pond 12

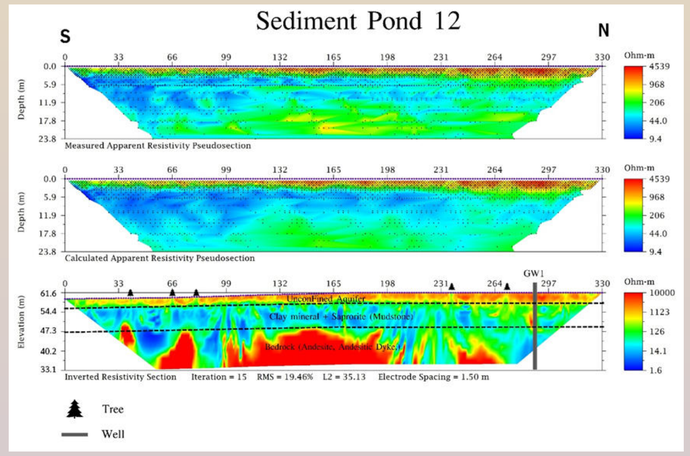


Fig 4. Cross-sectional profile 2D model, of ERT survey line in Fig 3. the black dashed lines indicate the boundary between rock layers.The subsurface was interpreted as three hydrostratigraphic units: (1) an upper lateritic layer, (2) an intermediate clay and weathered rock, (3) underlying bedrock associated with a deeper confined aquifer.

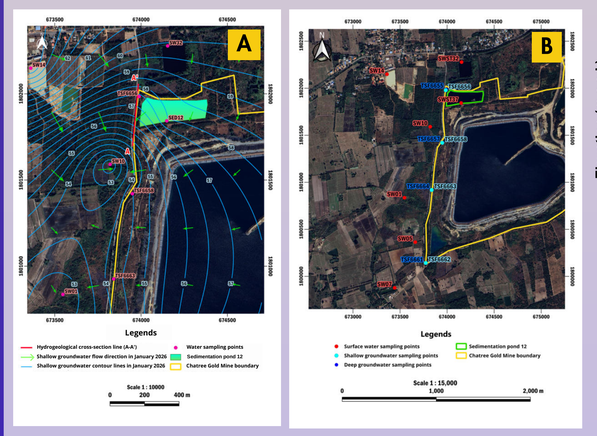


Fig 5. **(A)** A contour map of the shallow groundwater table with green arrows indicating the groundwater flow directions in the unconfined aquifer. The main directions of flow are from northeast to southwest in the southern side of the study area and from northeast-southwest directions in the eastern side of the study area, **(B)** A map of water sampling locations, **(C)** hydrogeologic cross-section (A–A′) showing the shallow groundwater level.

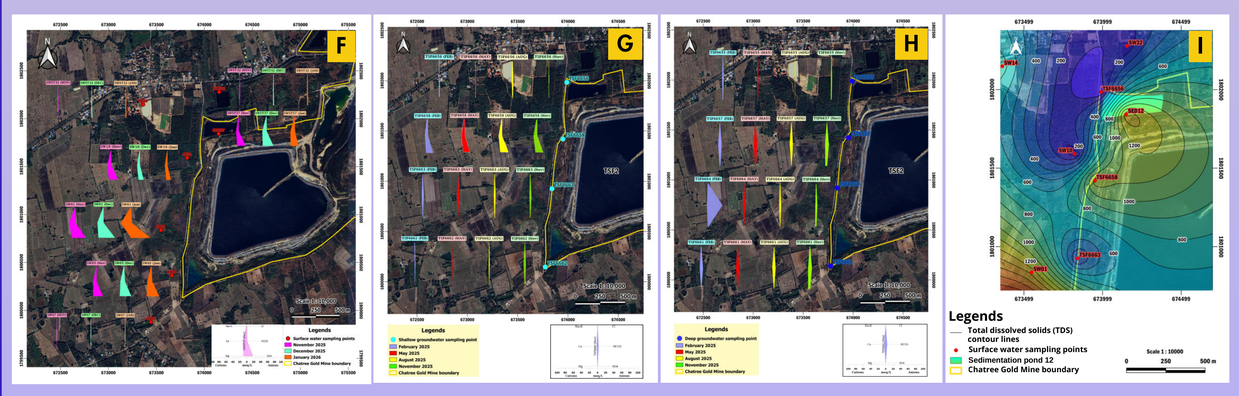


Fig 6. **(F)** Stiff diagrams of surface water samples, showing that most samples are characterized by a $Ca–SO_4$ water type, **(G)** Stiff diagrams of shallow groundwater samples, indicating that the dominant water type is $Ca–HCO_3$, **(H)** Stiff diagrams of deep groundwater samples, showing $Ca–HCO_3$ water type and **(I)** A spatial distribution map of Total dissolved solids (TDS), where the red and purple zones represent the highest and lowest TDS values respectively.

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