Factors Influencing Fluoride Contamination in Groundwater Resources of Eastern Chiang Mai-Lamphun Basin

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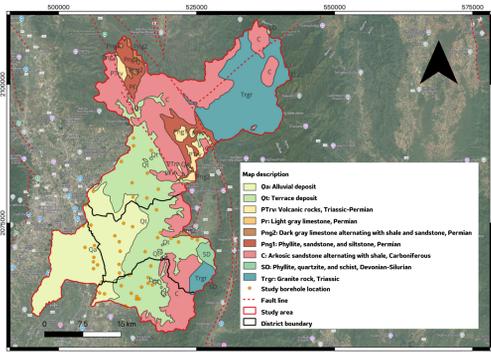
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Abstract

This study investigates fluoride contamination in groundwater resources in the eastern Chiang Mai-Lamphun Basin, which includes Doi Saket, San Kamphaeng, and Saraphi Districts in Chiang Mai Province, as well as Ban Thi District in Lamphun Province. These areas are known to be prone to elevated fluoride levels in groundwater. This research aims to assess contamination and distribution of fluoride and examine the factors influencing its occurrence in groundwater resources across the study area. A total of 50 groundwater samples were collected from groundwater wells with depths ranging from 25 to 438 meters in December 2024. The fluoride concentrations were analyzed using ion-selective electrode (ISE) analysis. Out of the 50 wells, there were 15 wells, predominantly in Ban Thi District, with fluoride concentrations exceeding the World Health Organization (WHO) standard of 1.5 mg/L. Additionally, 7 wells (3 in Ban Thi District and 4 in San Kamphaeng District) had fluoride concentrations exceeding the Ministry of Natural Resources and Environment (Thailand)'s drinking water standard of 0.7 mg/L. Statistical methods, including an examination of outliers, multicollinearity, normalization, and linear regression, have been conducted to analyze the data of all parameters. The analysis revealed that distance from fault exhibited multicollinearity with land use and rainfall, which could affect the model's accuracy. The correlation analysis indicates that precipitation, land use, and temperature have positive correlations with fluoride concentrations, with correlation coefficients of 0.4509, 0.3700, and 0.3024, respectively. For the linear regression analysis, the p-values for land use and temperature are 0.008 and 0.001, respectively, indicating a statistically significant relationship between these variables and fluoride concentration. However, as the correlation coefficients are quite low to moderate, the findings suggest that the selected factors do not significantly influence fluoride concentrations or fluoride accumulation processes in the study area. There might be other factors controlling fluoride level in this area such as rock units which should be further observed. Moreover, data limitation from the spatial analysis - interpolation techniques, utilized during data preparation processes, could affect the accuracy of the analysis.

Study areas

Fig.1 Geological map of the study area (modified from Department of Groundwater Resources, 2024 and Pailoplee, 2024)

4 districts from 2 provinces
- **Ban Thi:** 15 wells
- **Doi Saket:** 10 wells
- **San Kamphaeng:** 17 wells
- **Saraphi:** 8 wells
- **Total:** 50 wells

Objective

1. To investigate fluoride contamination in groundwater resources in Doi Saket District, San Kamphaeng District, Saraphi District of Chiang Mai Province and Ban Thi District of Lamphun Province.
2. To examine the factors influencing fluoride contamination in groundwater sources in Doi Saket District, San Kamphaeng District, Saraphi District of Chiang Mai Province, and Ban Thi District of Lamphun Province.

Methodology

1. **Field data collection:** Temperature, pH, conductivity and 50 ml. of groundwater
2. Ion Selective Electrode (ISE)
3. Mapping the distribution of fluoride using QGIS
4. Prepare data for statistical analysis
   - **Land use** - Point Sampling Tool
   - **Rainfall and slope** - Sample Raster Values
   - **Distance from fault** - Distance to Nearest Hub
   - **well depth**
5. Mean Normalization

$$X_{normalized} = \frac{X - \mu}{X_{max} - X_{min}}$$

   X= Independent variable
   Xmin= Minimum of Independent variable
   Xmax= Maximum of Independent variable
   Xnorm= The normalized value   μ= mean of the Independent variable

6. Linear Regression

$$Y = \beta_0 + \beta_1 X + \varepsilon$$

   Y= fluoride concentration.   X= Independent variable (land use, rainfall, distance from fault, well depth, slope)
   β0 = Intercept   β1= Regression Coefficient   ε = Error Term

References

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Thai Meteorological Department. (2024). Rainfall data for the year 2024. Retrieved from https://data-service.tmd.go.th

Santi Phailobli. (2024). Lithology data in shapefile format. Retrieved from https://drive.google.com/drive/folders/1
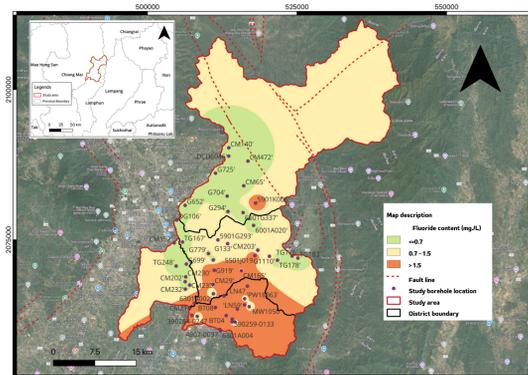
Results

Fig.2 Distribution of fluoride concentration map (modified from Department of Groundwater Resources, 2024 and Pailoplee, 2024)

15 wells have fluoride levels > 1.5 mg/L
- MW455, G919, LN59, CM214, BT04, 4902-0097, 5901K006, LN47, 390259-0133, BT03, BT08, 5501J019, 6301A004, MW176, 5901G293

7 wells have fluoride levels > 0.7 mg/L
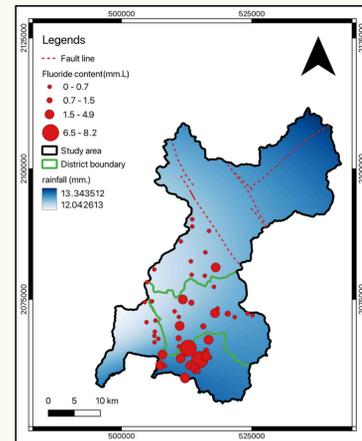- CM165, CM29, BT01, PW18063, G1110, G133, BT07

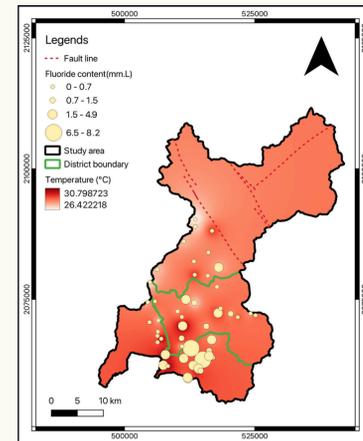Fig.3 Rainfall map (modified from Thai Meteorological, 2024 and Pailoplee, 2024)

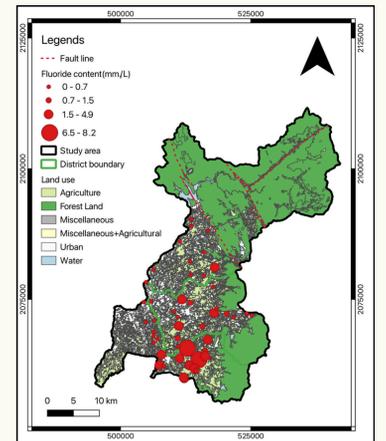Fig.4 Temperature map (modified from Pailoplee, 2024)

Fig.5 Land use map (modified from Land Development Department, 2024 and Pailoplee, 2024)
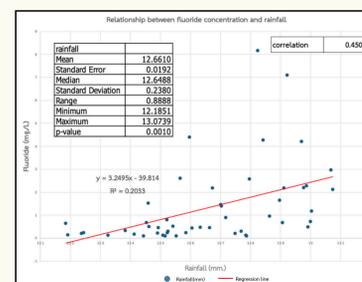

Fig.6 Scatter plot showing the relationship between fluoride concentration and rainfall.
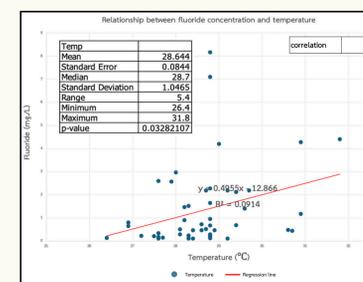

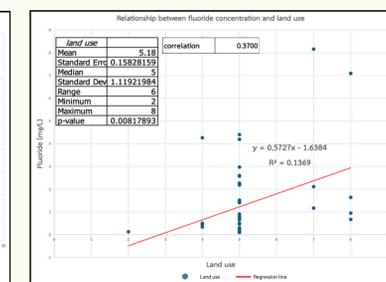Fig.7 Scatter plot showing the relationship between fluoride concentration and temperature.

Fig.8 Scatter plot showing the relationship between fluoride concentration and land use.

Conclusion

- There is fluoride contamination, exceeding the WHO standard (1.5 mg/L), in the northwest region of Ban Thi District.
- Although the correlation and regression analysis suggest positive correlations between fluoride concentrations and parameters - rainfall, land use, and temperature, these factors do not significantly influence fluoride levels in the study area as the correlation coefficients are low to medium. Other reportedly influencing factors, such as rock units, should be further explored.

Acknowledgement