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Machine learning approaches and remote sensing applications to assess groundwater radioactivity in arid environments

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In this study, we developed and used an automated machine learning (AML) approach to quantify relationships between gross α and gross β activities and different geological, hydrogeological, and geochemical conditions. Two AML model groups (group I for gross α; group II for gross β) were constructed, using water samples collected from 360 irrigation and water supply wells, to define a robust model that explains the spatial variability in gross α and gross β activities, as well as variables that control the gross activities. Each group contained four model families: deep neural network (DNN), gradient boosting machine (GBM), generalized linear model (GLM), and distributed random forest (DRF). Model inputs include chemical compositions as well as geological and hydrogeological conditions. Three performance metrics were used to evaluate the models during training and testing: normalized root mean square error (NRMSE), Pearson's correlation coefficient (r), and Nash-Sutcliff efficiency (NSE) coefficient. Results indicate that (1) the GBM model out performed (training: NRMSE: 0.37 ± 0.10; r: 0.92 ± 0.05;NSE: 0.85 ± 0.09; testing: NRMSE: 0.71 ± 0.08; r: 0.72 ±0.08; NSE: 0.49 ± 0.12) the DNN, DRF, and GLM models when modelling gross α activities; (2) gross α activities are controlled by pH, stream density, nitrate, manganese, and vegetation index; (3) the DRF model outperformed (training: NRMSE: 0.41 ± 0.05; r: 0.92 ± 0.02; NSE: 0.83 ± 0.04; testing: NRMSE: 0.67 ± 0.09; r: 0.77 ± 0.07; NSE: 0.54 ±0.12) the GBM, DNN, and GLM models when modelling gross β activities; (4) input variables that affect the gross βactives are pH, temperature, stream density, lithology, and nitrate; and (5) no single model could be used to model both gross α and gross β activities—instead, a combination of AML models should be us In this study, we developed and used an automated machine learning (AML) approach to quantify relationships between gross α and gross β activities and different geological, Hydro geological, and geochemical conditions. Two AML model groups (group I for gross α; group II for gross β) were constructed, using water samples collected from 360 irrigation and water supply wells, to define a robust model that explains the spatial variability in gross α and gross β activities, as well as variables that control the gross activities. Each group contained four model families: deep neural network (DNN), gradient boosting machine (GBM), generalized linear model (GLM), and distributed random forest (DRF). Model inputs include chemical compositions as well as geological and hydrogeological conditions. Three performance metrics were used to evaluate the models during training and testing: normalized root mean square error (NRMSE), Pearson's correlation coefficient (r), and Nash-Sutcliff efficiency (NSE)coefficient. Results indicate that (1) the GBM model out performed (training: NRMSE: 0.37 ± 0.10; r: 0.92 ± 0.05;NSE: 0.85 ± 0.09; testing: NRMSE: 0.71 ± 0.08; r: 0.72 ±0.08; NSE: 0.49 ± 0.12) the DNN, DRF, and GLM models when modelling gross α activities; (2) gross α activities are controlled by pH, stream density, nitrate, manganese, and vegetation index; (3) the DRF model outperformed (training :NRMSE: 0.41 ± 0.05; r: 0.92 ± 0.02; NSE: 0.83 ± 0.04;testing: NRMSE: 0.67 ± 0.09; r: 0.77 ± 0.07; NSE:0.54 ±0.12) the GBM, DNN, and GLM models when modelling gross β activities; (4)input variables that affect the gross βactives are pH, temperature, stream density, lithology, and nitrate; and (5) no single model could be used to model both gross α and gross β activities—instead, a combination of AML models should be used.ed.

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