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Application of an Artificial Neural Network for evaluation of activity concentration exemption limits in NORM industry

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Content

Naturally occurring radionuclides such as 40K and the decay products of the primordial radionuclides 232Th, 235U and 238U are present in many natural resources. Naturally occurring radioactive materials (NORM) containing these radionuclides are exploited by industrial endeavours and often exceed the exemption limits of the activity concentration for radionuclides of the U and Th series, depending on mineral composition and geological origin. Industrial activities are generating a significant portion of waste and can enhance the potential of exposure of workers and the public. Furthermore, the management and deposition of material above the exemption limit is very costly. The European Metrology Research Project MetroNORM focuses on creating traceable, accurate, and standardised measurement methods, reference materials and systems for (in-situ) application in the concerned industries. The main problem with measuring NORM lies in the variety of densities and compositions of the materials. NORM emits many gamma-rays of different energies that have to be measured and analysed by an expert. Furthermore, the sample activity often barely exceeds the background and long measuring times and expert knowledge for analysing the spectrum are required. One alternative way to approach the problem is the use of artificial neural networks (ANNs). ANNs are mathematical software tools that emulate the way the human brain works. They are trained, tested and validated with sample datasets and capable of "learning by doing". They can generalise the "knowledge" gained by the content of the training set and apply it to new problems. This can be viewed as a new calibration tool where no expert knowledge of gamma-ray spectrometry is needed by the end-user. In this work an ANN was created in the frame of MetroNORM that is able to decide from the input data of a raw gamma-ray spectrum if the activity concentrations in a sample are above or below the exemption limits. To train the network, six NORM reference materials have been analysed and measured. A total number of twelve interference-free lines relevant to the NORM industry were chosen for analysis by the ANN. To widen the applicability of the algorithm, a set of artificial gamma-ray spectra with varying density, activity concentration and material composition has been created using the Monte Carlo codes PENELOPE 2014 and PENNUC (CIEMAT) for training, testing and validation of the ANN. Furthermore, different states of broken equilibrium have been studied for these materials and used as training data. In order to classify the activity content of the input samples five activity categories (on the exemption limit, two near but above and below the exemption limit, far above or below the exemption limit) were chosen. The resulting ANN is a feed forward artificial neural network consisting of one hidden layer containing 31 hidden nodes using a backpropagation algorithm and a logarithmical transfer function to adjust the connection weights. The ANN was able to classify the testing materials (that have not been used as training data) correctly. The results show that the approach is feasible and has great potential for application in the concerned industries.

About the Presenter

The presenter studied physics at the Technical University of Vienna and is now working at the Austrian Federal Office of Metrology and Surveying. She was granted an Early Stage Research Mobility Grant by EURAMET and has researched ANNs at CIEMAT/Spain.

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