OPTIMISATION OF DREDGING WORKS USING NUCLEONIC GAUGE FOR VERTICAL DENSITY PROFILES MEASUREMENT

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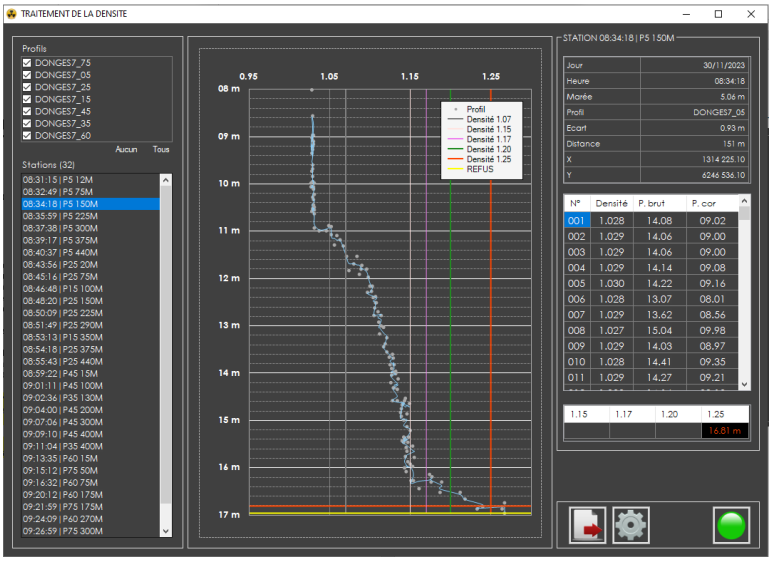
ABSTRACT

There is a continuous inflow of sediments in ports and access channels and therefore maintenance dredging is necessary. To determine when and how much there needs to be dredged the underwater sediment and mud layers must be monitored and analysed. This paper presents an innovative vertical profiling technique measuring the depth, thickness and density of the underwater sediment layer. The instrument uses X-ray to measure the sediment density. The data is used for two important aspects.
First in the preparation of dredging works where the data is used to determine ton dry matter of the dredged material. In combination with acoustic methods like multibeam echo sounders it is used to visualize the sediment layers under a multibeam surface.
Another important aspect of soft sediment is the navigability. Ships can navigate through loose mud layers if the physical characteristics of the mud stay below a critical limit. Today the measured physical characteristic in many ports is density. The proposed measurement technique allows visualization of density and enables ports to evaluate nautical depth criteria.

In the Port of Nantes Saint-Nazaire, data from the density profiler combined with data from single beam echosounder are daily used to determine the navigation depth in the channel and along the docksides. After data analysis, nautical charts are produced and diffused to accommodate ships in complete safety. When the measured depths do not respect the theoretical depths, these charts allow to define dredging zones to maintain access.



Example of a density profile

Keywords: Mud density, Nautical depth, Maintenance dredging

Measurement and Analysis of Radionuclides in Soil Samples Collected from Neutral and Cultivated Land Employing HPGe Detectors

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The omnipresence of natural radiation is inherent to life on Earth, prompting the investigation of natural radioactivity in specific geographic regions through soil, water, and air sample analysis. Concentrations of radionuclides (e.g., ^{238}U, ^{232}Th, and ^{40}K; with $T_{1/2}=10^9$ to 10^{10} years) in the soil directly affect the food chain eventually posing health risks [1]. Among many, gamma-ray spectrometry employing HPGe detectors is an advanced technique for identifying and quantifying radionuclides in soil samples, favoured globally for their superior energy resolution [2].

For the present work, key characteristics (i.e., efficiency including close scanning, resolution, peak shape, etc.) of n and p-type coaxial HPGe detectors have been investigated to optimize their performance for soil samples analysis in a range of 40–1408 keV using various gamma sources [2]. Radionuclide concentrations in soil samples from neutral and cultivated lands in Punjab, India, have been measured using HPGe detectors. Note that the neutral land was free from human alterations for over a decade, while the cultivated land was heavily used for cultivation. The mean activity concentrations of ^{238}U, ^{232}Th, and ^{40}K in neutral terrain has found to be 58.03, 83.95, and 445.18 Bq kg^{-1}, respectively. In contrast, these concentrations in cultivated land have been estimated to be 40.07, 64.68, and 596.74 Bq kg^{-1}, respectively. It may be pointed out that the radium equivalent activity was below the safe limit of 370 Bq kg^{-1}, but the annual effective gamma dose rate exceeded the global mean in both areas. Elemental radionuclide concentrations in soil samples from both lands were compared, followed by assessing concentration ratios (as showcased in Figure 1) to determine if they were within the natural range. The detailed findings of this work will be presented during the conference.

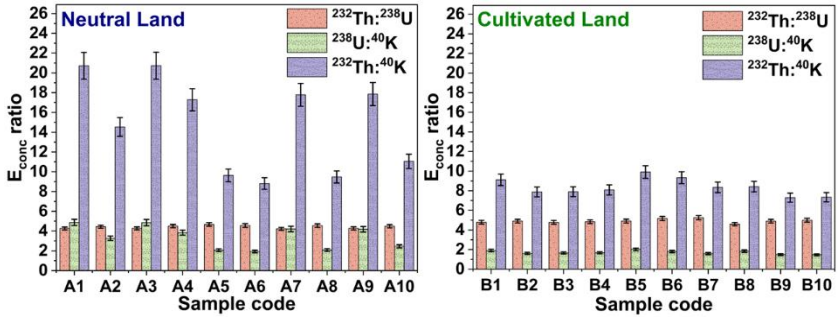

Figure 1- Elemental concentration (E_{conc}) ratio between different soil samples collected from neutral and cultivated land

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Atmospheric Concentrations of Radioactive Isotopes and Trace Elements in Helsinki, Finland

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16070 daily and 608 weekly air filters from the Helsinki metropolitan area, Finland for the period 1962–2005 are analyzed. Based on such a large data set and by studying the elemental and radioactive concentrations (especially of ^{210}Pb), the effect of different anthropogenic pollutants on the atmosphere and the environment in general was achieved. The daily filters were analyzed to determine the concentrations of the radioactive isotope ^{210}Pb, while the weekly filters were analyzed and measured simultaneously to determine the concentrations of 17 different trace elements in the atmosphere (Na, Al, Si, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Br, Pb). Radioisotope concentrations were completed with the appropriate automated alpha and beta radiation analyzer. In addition, the weekly filters were properly prepared and measured using the Epsilon 5 high-resolution X-ray spectrometer. Most elements show a downward trend over the years. On a percentage basis, concentrations of trace elements and ^{210}Pb have decreased significantly. The smallest decrease concerns the elements Cu, Br and Cl, while the largest has been observed for the element Pb (Na: 74%, Al: 86%, Si: 88%, S: 82%, Cl: 22%, K: 82 %, Ca: 89%, Ti: 80%, V: 89%, Cr: 82%, Mn: 77%, Fe: 77%, Ni: 61%, Cu: 37%, Zn: 72%, Br: 32 %, Pb: 95%, 210 Pb: 51.6%). Trace element sources were determined based on matrix positive factor analysis using SoFi software. Four sources of particulate matter (PM) were identified: road dust (due to use of leaded fuel), secondary combustion of heavy oil/sulphate, traffic emissions and natural dust (soil). For the total of 44 years, significant decreases in concentrations were observed for all elements, most of which were over 50%: Na(-74%), Al(-86%), Si(-88%), S (- 82%), K(-82%), Ca(-89%), Ti(-80%), V(-89%), Cr(-82%), Mn(-77%), Fe(-77 %), Ni(-61%), Zn(-72%) and Pb(-95%). In general, a significant decrease in most elemental concentrations has been observed since the late 1970s, which underlies the effectiveness of the different environmental policies implemented. To understand the spatial origin and potential sources of pollutants, the Probable Source Contribution Function (PSCF) analysis was applied, which calculates the probability for each area of a potential pollutant source, based on the frequency of high concentrations. From the trajectory analysis, it emerged that Finland is an area directly affected by transboundary pollution, mainly from air masses coming from its eastern border (air masses from Russia), but also from areas of Northern Europe. In these source areas there is intense industrial activity and energy production facilities, with the result that the air masses coming from there are enriched with several gaseous pollutants, containing both trace elements and radioactive isotopes.

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Experimental studies on the diffusion of metallic fission products in Uranium Mononitride (UN) and Uranium Dioxide (UO_2)*

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Uranium mononitride (UN) is an attractive fuel for passively safe fast reactors due to its advanced properties. It combines high thermal conductivity, high uranium density and offers the potential of a closed fuel cycle. On the other hand, uranium dioxide (UO_2) is the most common fuel used in nuclear industry. Both fuels are interesting candidates for advanced reactor systems such as Generation IV and Small Modular Reactors (SMRs). The fission products (FP) generated in the nuclear fuel during fission affect the physical, mechanical and thermal properties of the fuel.

In this work, we present an innovative study on the diffusion of metallic FPs in both UN and UO_2 fuels and the change in fuel properties due to the presence of FPs. High-purity UN powder was fabricated from uranium metal [1]. Spark Plasma Sintering was used to consolidate the powders into pellets [2]. UO_2 pellets were provided by Westinghouse Electric Sweden AB for this study. Zirconium (Zr) and barium (Ba) were chosen as representative FPs since they interact in different ways with the fuel: Zr forms a solid solution whereas Ba precipitates in the matrix. A high-current implanter was used to implant Zr and Ba in the pellets. Annealing in an oxygen-free environment was performed to obtain Zr and Ba diffusion data using time-of-flight elastic recoil detection analysis (ToF-ERDA). Scanning electron microscopy (SEM) and energy-dispersive spectroscopy (EDS) were employed to investigate possible changes in the sample microstructures and compositions induced by the presence of FPs and compare the results with those obtained by ToF-ERDA. Microscopy and image analysis techniques were used to study potential swelling induced by Ba implantation.

The results obtained provide valuable insights on the diffusion of the solid FPs in UN and UO_2 and highlighting the importance of the experimental method in understanding complex behaviors.

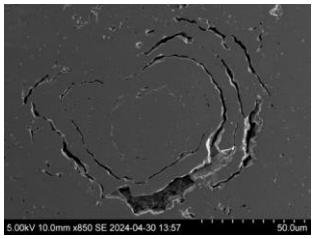
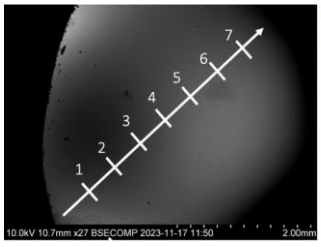


Figure 1- UO_2 microstructure under SEM, after Zr implantation.



Spectrum	N at%	O at%	Zr at%	U at%
1	26	21	5	48
2	29	18	2	51
3	29	18	0.8	52
4	31	15	0.3	54
5	32	13	0.2	55
6	32	12	0.2	56
7	33	10	0.1	57

Figure 2- UN under microscope, after Zr gradient implantation.

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Analysis of Environmental Radioactivity in Korça District Using Advanced Computational Techniques

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The study presented in this paper is focused on the assessment and determination of environmental radioactivity in Korça district. We conducted a total of 37,340 measurements over the past three years. We found that the dose rates ranged from a minimum of 0.015 μSv/h to a maximum of 0.21 μSv/h, with an average of 0.054 μSv/h. The measurements were performed with the device Backpack Atomtex AT6101C in different populated areas, both urban and rural areas of Korça district. We used the languages of the R program and of MATLAB to analyse the measured values. In the beginning, we analysed the summers data and their averaging. The data were processed and selected to optimize the spatially distributed dose values. Data clustering was performed to group those measurements that have more approximate spatial values to achieve a representative grid of measurements. This new grid of measurements was mapped using ArcGIS-PRO as coloured dots according to dose power. Maps were also built in ArcGIS-PRO and in MATLAB, where a complete coverage of the entire area was made using the Kriging method. The distribution of values was studied and fitted to some known distributions. Through loglikelihood and the $\chi 2$ test, the truth of the hypothesis that the distribution of the measurements fits the widely known distributions was tested. This approach allows for precise interpretation of the collected data. Measurements and analyses across Korça district confirm that natural radiation levels are very low and do not pose any health risk to the population.

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Nuclear techniques for tracking the progress of the leaching process of Mn from Ti ore and mining waste samples*

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Non-destructive radiometric analytical methods are very competitive in a wide range of applications. A typical example is the investigation of the hydrometallurgical process of leaching metals from ores and mining waste. The objective of this study is to develop a radiometric method based on the neutron activation method to track the process of Mn leaching from Ti ore, Cu mine tailings, and Zn-Pb tailings. The DGNAA method was performed using a neutron source: a deuterium-tritium neutron generator (D-T NG) for Mn. Laboratory-scale Mn leaching process was investigated using delayed gamma-rays of 56Mn (half-life of 2.6 hours). Mn leaching was found to increase with acid concentration (1 to 5 M), and recovery time, and it varied with the leaching temperature (20 to 110°C). The developed mathematical model based on the Noyes–Whitney equation modified by Nernst and Brunner for leaching of Mn showed that the spherical diffusion model requires a lot less time to attain saturation level compared to the linear diffusion model. The neutron activation analysis results for Mn were confirmed with X-ray fluorescence and total reflection X-ray fluorescence (TXRF) analysis done on the leached samples under different conditions of temperature, leaching time, and acid concentrations. The XRF analysis confirmed the observed trend such as the increase of Zn concentration in liquid with leaching time, and HCl concentration, and varies with leaching temperature. This approach can be applied in the industrial setup for online monitoring of the recovery of different elements, which isotopes can be activated by the neutrons.

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