Assessing Radiological Threats to Ecosystems: A Case Study Perspective

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The contamination of both terrestrial and aquatic ecosystems by toxic industrial waste has emerged as a significant concern in numerous countries. Of particular alarm is the repurposing of toxic hazardous waste in the production of construction materials.

This recently published study [1] represents the first examination of the chemical and radiation ecotoxicity of site-specific Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) residues from the phosphate processing industry within soil environmental matrices, employing bioindicators. TENORM wastes containing phosphorite rocks, as the ones contaminating the analyzed Crotone area, are characterized by the presence of radioactive phosphogypsum and metasilicates, containing radionuclides from ^{238}U and ^{232}Th decay series which are of most radiotoxicity [2].

The study area encompassed the former industrial district of Crotone in Calabria, Italy, which has recently been designated as a Site of National Interest (SIN), constituting one of the 42 Italian national priority contaminated sites.

Three primary biological assays were employed in the investigation. The marine bacterium Vibrio fischeri and the freshwater crustacean Daphnia magna were utilized as bioindicators for aquatic ecosystems, while the seeds of Sorghum saccharatum and Lepidium sativum were employed to represent the soil ecosystem. The selection of these test species aimed to evaluate the toxicity of wastes in both soil and freshwater or marine environments.

Results revealed that V. fischeri exhibited the highest sensitivity among all tested species (5.56 g/L), whereas D. magna displayed effects at a concentration of 94.27 g/L. Overall, there was a notable inhibition in seedling growth compared to the control group at the highest concentration of pollutants (100 g/L), although seed germination remained unaffected by the pollutants.

At this preliminary stage, the data suggest a potential risk to the biodiversity of the area. Despite toxicity thresholds measured above 100 mg/L, they are comparable to concentrations of the toxicants found throughout the territory of Crotone.

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Radiotracers for the study of Marine and Oceanic Ecosystems: The REMO project

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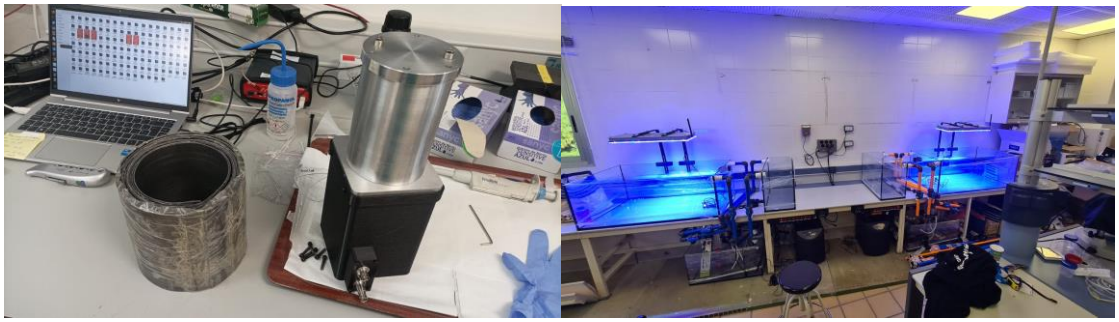
The industrial revolution released massive CO_2 molecules to the atmosphere, starting from 170-280 parts per million in the XIX century up to 418 in 2023 [1]. Recent studies have shown that oceans absorbed about 22% of this anthropogenic CO_2 between 2008-2017 [2]. Carbon dioxide reacts with water producing carbonic acid (H_2CO_3), which lowers the pH, producing the so-called ocean acidification. The latter, combined with global warming, has a vast anthropogenic effect on marine ecosystems and oceanic currents influencing negatively the physiology and ecology of marine ecosystems. For instance, it has already been proved that coral communities are particularly affected by rapid changes in environmental conditions [3].

As coral and bivalve mollusks build their exoskeletons and shells respectively through the production of calcium carbonate ($CaCO_3$), the influence of seawater acidification on the Calcium growth and uptake of these organisms can be studied through the use of Calcium-45 radiotracer in different acidity conditions [4,5]. The REMO (Radiotrazadores para el estudio de Ecosistemas Marinos y Oceánicos) project focuses on the study of marine species heavily impacted by acidification. Specifically, we aim to monitor, using radiotracers (^{45}Ca) by means of non-destructive techniques, the growth and Calcium uptake in various corals and bivalve mollusk species, vital for their survival in their ecosystems. In this way, the same individual and the entire colony can be observed during their life-time, typically spanning in periods of months or years, determining the impact at any stage of the life-cycle.

The non-destructive techniques represent a technological challenge from the nuclear experimental standpoint since it requires the development of specific, high sensitivity, nuclear instrumentation able to detect the small radiotracer activity in a somewhat “hostile” environment and without impacting on the animals: short time measurements, non chemical exposure..etc.

Such a complicated and transversal project is only possible because of the joint effort of biology and nuclear physics, combining the expertise and experience of marine biologists from the Valencia Oceanografic together with the nuclear physicist experience from the Instituto de Física Corpuscular.

At the time of the conference, we will present the status of the project, the nuclear detector developments and first measurements planned this summer at the Oceanographic facility.



Left: Prototype for ^{45}Ca radiotracer detection. Right: Aquarium station at the Valencia Oceanographic.

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Determination of radionuclides and non-radioactive trace elements in environmental aerosols

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The study of environmental radioactive aerosols and fallout radionuclides (FRN) has been one of the research activities at the Nuclear Engineering Laboratory of the National Technical University of Athens (NEL-NTUA) for many years. For this purpose, a High-Volume Air Sampler (DH-50810 by F&J Specialties) and 8"x10" glass-fibre filters are being used. This on-going research has already resulted to the detection and quantification of ^{7}Be [1], ^{210}Pb and in a few cases ^{22}Na - though the later with poor statistics [2]. The detection capabilities at NEL-NTUA were recently improved with the supply of a Mega High Volume Air Sampler (GAS-604657-MHVE, by F&J Specialties).

In this study, a comprehensive investigation undertaken at NEL-NTUA, which focused on the improvement of the detection capabilities of radionuclides and trace elements in environmental aerosols, using the two High Volume Air Samplers is presented.

To this end, filters simultaneously collected with the two Air Samplers are analysed at NEL-NTUA using γ-spectroscopic analysis, X-Ray Fluorescence (XRF) and Neutron Activation Analysis (NAA). For the γ-spectroscopic and Neutron Activation analysis an XtRa Ge detector (104% rel. eff.), along with a Compton Suppression system is used. For the neutron activation of the air-filters a 10Ci Am-Be thermal neutron source is used, while the XRF analysis is performed with the use of an X-ray tube (0-50kV, up to 1mA) and a Super SiLi detector.

In this paper a detailed description of the procedures followed for (i) the calibration of all three analytical procedures, (ii) the different air filter sample preparation and geometry optimization, (iii) the determination of filter background in terms of trace elements and (iv) the determination of the limits of detection for all trace elements and the Minimum Detectable Activity (MDA) for radionuclides likely to be detected, are presented in detail.

The results of this research will provide the foundation for consistent and efficient monitoring of environmental aerosols at NEL-NTUA, with the parallel operation of the two air samplers and the most efficient methodology for handling and analyzing the air filters.

Furthermore, very useful information regarding radionuclides, their ratios and trace elements existing in environmental aerosols and the Sahara dust, are obtained by sampling during normal periods and during Sahara dust events.

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Radiometric methods in two-phase flows *

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Application of a radiometric system, consisting of two closed sources of gamma radiation (Am-241) allows for determining the parameters of liquid-gas flows [1] (Fig. 1a) and liquid-solid particles [2] (Fig. 1b) in closed conduits. An in-depth analysis of the signal from the measurement system results in the determination of the following quantities: void fraction [3] or concentration of solid particles [4], average flow velocity of the minority phase [5], and also recognition of flow structures [6]. The indicated measurement possibilities will be illustrated with examples:

a) water-air flow in a horizontal pipeline, for average water speed (1.2-3.2) m/s, average air flow speed (1.0-2.2) m/s,

b) water-solid particle flow in a vertical pipeline, for average water velocity (2.0-4.6) m/s, average solid particle flow velocity (0.3-3.4) m/s.

Additionally, the possibility of cooperation with other flow meters in order to obtain full information about multiphase flows will be demonstrated. And in the case of hydrotransport of solid particles, it is combined with radiotracer experiments [2].

a) b)

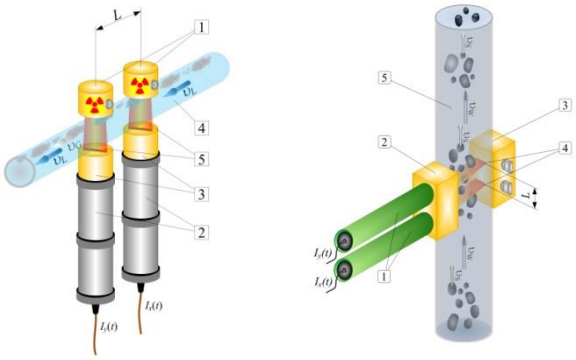

Fig. 1. Gamma absorption flow velocity measurement principle: 1 – collimators with radioactive source, 2 – scintillation probes, 3 – collimators of detectors, 4 – pipeline with flowing mixtures, 5 – gamma-ray beam, L – distance between probes, $I_x(t)$, $I_y(t)$ – signal from probes, υ_G – gas velocity, υ_L – solid particles velocity, υ_L, υ_w – liquid (water) velocity [2, 5].

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Influence of Environmental Factors on Indoor Radon Concentration: A Case Study of a University Laboratory

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Commonly known that people are exposed to radon and its progenies since they spend about 90% of daytime at indoor. Radon, a well-established risk factor for lung cancer, is present in most indoor. The measurement of indoor radon concentration should be performed to set down the radiological risk set off by short-lived radon decay products. There are many important parameters that affect the indoor radon such as meteorological parameters, geology, building materials, outdoor and indoor air exchange, and ventilation-related physical and climatic factors, human behavior, and radon mitigation techniques. While meteorological factors like temperature and humidity can also affect indoor radon levels, proper ventilation is crucial.

The study assesses the correlation between indoor radon concentrations with temperature, humidity, and pressure, as well as environmental variables. Indoor radon concentrations were measured at Ege University Faculty of Science from November 2020 to July 2021on floors of approximately the same projection in the same building to examine environmental parameters affect radon concentration. After statistical analysis, the results were compared to committee-permissible limit levels (ICRP, WHO, and EU). It was found that the average radon activity concentrations were below the recommended 300 Bq m–3 limit value (EU), ranging from 58.4 to 216.0 Bq m–3. This study emphasized the significance of measuring and assessing the indoor radon levels in laboratories and classrooms in particular, in order to safeguard the students and faculty members from radon-related health issues [1,2,3,4,5].

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