Assessment of radiologically contaminated land

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Abstract: *Contaminated land assessments range from routine to complex tasks in accordance with the contaminants and their interaction within the environment. This is particularly true where the (or a) contaminant is radioactive. As such, the radionuclides present and their physical or chemical form are significant to their detection and measurement, as well as their behaviour in the environment, and most importantly potential radiological exposures. Moreover interpretation and application of relevant regulatory governance and radiation protection practices can be unique to each radiologically contaminated site. This presentation discusses radioactive contaminants, such as heavy mineral sands with enhanced concentrations of natural radioactivity. This is discussed with a focus on the importance of input from a Health Physicist or radiation professional in the assessment of radiological contaminants.*

Introduction: Contaminated land assessments follow generic processes such as those outlined in the NEPM document (NEPC 2013). The application of these processes is tailored to each assessment in accordance with the site and anticipated contaminants. Radiological contaminants can vary significantly; they can be bulk quantities of low specific activity material or high activity discrete sources; they can be robust and insoluble, or soluble and highly mobile. As a consequence, the assessment of radiologically contaminated land is best addressed with the input of a suitably experienced Health Physicist or radiation professional.

Health Physics: The profession of health physics focuses on protecting people and the environment from potential radiation hazards, with common fields of expertise being regulatory, medical, nuclear and environmental.

Contamination Compliance Criteria: Radiological site assessments should be tailored to effectively investigate and characterise contaminants appropriate for comparison with compliance criteria. Compliance criteria are often based on exposure by applying dose limits. Traditionally using dose limits for the protection of humans was considered to also reasonably address protection of the environment. This approach is still well founded, however direct consideration of radiological impacts on biota is gaining momentum.

Radiological Site Assessments: At a minimum, radiological site assessments normally consist of walk-over gamma radiation surveys and laboratory analysis of samples. These assessments generally provide results in dose rates and activity concentration respectively, resulting in a need for correlation to contamination criteria, namely total effective dose. This requires factoring in exposure parameters such as site occupancy, exposure pathways and radionuclide specific conversion factors. Moreover correlation of measurements with contamination criteria is reliant upon the validity of initial measurements, for instance the use of a suitable environmental level gamma radiation survey meter, with relevant calibration information. Additionally it is good practice to establish background levels so that compliance criteria can be compared with background corrected values.

Sources of Radiation: Radioactive materials can originate from natural and anthropogenic sources, both of which are integrated into modern societies. Governance provided by radiation regulatory authorities differ in detail, but have common underlying principles, particularly in regard to when radioactive material is of sufficient activity and/or activity concentration to warrant controls such as licensing, transport, storage and disposal; and all with the paramount focus on radiation safety and protection. These regulatory controls are applied in consideration of the radionuclide's emissions, physical and chemical form. Likewise, criteria for determining whether radioactive material constitutes a site contaminant require similar considerations along with the potential for radiological exposure to humans and the environment.

Anthropogenic radioactive material can vary in physical and chemical form and their interaction with the environment. Being man-made they are usually produced and used with due consideration to the benefit they provide compared with their potential for harm such as through improper disposal thereby potentially contaminating land. As a result of this, where anthropogenic radiological site contaminants exist, this may be the result of something having gone awry, or where formerly accepted practices are substandard compared with current practices. An example of the latter is the use and progressive disposal of radium-226 in luminescent paints, such as on aircraft instrumentation dials. An example of things going awry is the inadvertent disposal of sealed sources into landfill and metal recycling. An extreme event is the accident in 1987 in Goiania, Brazil which resulted in widespread radiological contamination and human exposure (IAEA 1988).

Naturally occurring radioactive material (NORM) in contaminated land assessments frequently pertain to radionuclides in the uranium-238 and thorium-232 decay chains. Elevated concentrations of NORM are associated with natural resource industries like uranium mining, metal mining, mineral sands, phosphate fertilizer, coal, oil and gas. In these industries, radionuclides can accumulate in products, by-products and wastes as a result of mining, combusting or processing the natural materials, for example scale from oil and gas industries.

Heavy Mineral Sands: Commonly encountered mineral sands are ilmenite, rutile, zircon, monazite and garnet. These have different concentrations of radionuclides in each the uranium-238 and thorium-232 decay series' plus this varies depending on geological origin. Of the aforementioned sands, monazite has the highest concentration of NORM, whereas ilmenite is relatively low. Mineral sand products often contain impurities of other mineral sands as a result of the efficacy of separation plant processing. Therefore two different supplies of ilmenite could contain different concentrations of monazite and hence have different radiological impacts. This exemplifies why two abrasive blasting sites may be similar in history and physical appearance but different in radiological characteristics. Moreover it is commonplace for sites to contain mineral sands that are partially mixed with other site soils, often resulting in material of generic appearance which at different sites or different locations on the same site can have wide ranging radiological characteristics. Due to the prevalence of these circumstances it is very difficult to assess the potential for radiological contaminants to be present on sites with a history involving mineral sands without a radiological site characterisation.

Conclusion: Radioactive contamination of land occurs due to anthropogenic and natural radioactive materials and can present anywhere in the spectrum from simple to complex circumstances. The impact of radiological contaminants and hence defining criterion for compliance or categorising the level of contamination is often on a basis of dose. Factors such as land use, exposure pathways and species of radionuclides present, are critical in the determination of a dose from radiological measurements. In conclusion, intricacies in the assessment of land where radioactive material is potentially a contaminant warrant the involvement of a radiation professional, both from a scientific justification and in prudence from a radiation safety perspective.

References:

IAEA (1988). The radiological accident in Goiania. Vienna, International Atomic Energy Agency.

NEPC (2013). National Environmental Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1), National Environment Protection Council.