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Editorial

Radioactivity: Sustainable Materials and Innovative Techniques

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Radioisotopes, also known as radionuclides, are atoms with unstable nuclei that emit ionizing radiation. Radioisotopes have a wide range of applications in medicine, industry, and scientific research, including in cancer diagnosis and treatment, sterilization of medical equipment, and dating of geological and archaeological materials [1,2]. However, the use of radioisotopes also poses significant risks to human health and the environment due to their potential for radioactive contamination and exposure [3,4].

Radioactive waste management is a critical component of nuclear safety. It involves the safe and sustainable disposal of nuclear waste generated from various sources, including nuclear power plants, medical facilities, research facilities, and industrial processes [5]. With the advancement of technology and scientific research, innovative approaches to radioactive waste management have emerged, ensuring sustainable nuclear safety [6].

Waste management and nuclear safety are critical issues that need to be addressed with utmost seriousness. Proper waste management ensures that the environment and the public are not exposed to harmful materials, while nuclear safety measures are necessary to prevent accidents and incidents that could result in radiation leaks [7–9].

Waste treatment and disposal methods are crucial components of waste management. Several methods are used for waste treatment, including recycling, incineration, and landfilling. Recycling involves converting waste materials into new products or materials, while incineration involves burning waste materials to reduce their volume and weight [10]. Landfilling is the most common method of waste disposal, where waste is buried in a designated area [11].

Nuclear waste, which is generated from nuclear power plants, research facilities, and medical institutions, requires special treatment and disposal methods due to its radioactive nature. The most common method of nuclear waste treatment is reprocessing, which involves extracting useful materials from nuclear waste [12]. The remaining waste is then disposed of in specialized facilities designed for storage or final disposal [13].

Nuclear safety measures are critical to prevent accidents that could lead to radiation leaks. Nuclear power plants are designed with multiple layers of safety systems, including automated shutdown systems and emergency cooling systems. Regular inspections, maintenance, and training of personnel are also necessary to ensure nuclear safety [14].

Overall, waste management and nuclear safety are complex issues that require a comprehensive approach. Governments, industries, and individuals must work together to develop effective waste treatment and disposal methods while also implementing strict safety measures to prevent nuclear accidents [15].

Innovative approaches to radioactive waste management are critical for ensuring sustainable nuclear safety [16]. The use of natural materials, radiation techniques, and waste management methods can ensure the safe and sustainable disposal of radioactive waste generated by various sources, including nuclear power plants, medical facilities, research facilities, and industrial processes [17]. These innovative approaches ensure the protection of the environment and public health, while also promoting sustainable nuclear safety. Several sustainable materials have been used in nuclear applications such as cellulosic waste in treatment [18,19] or cement mixed with bitumen [20,21], cement waste [22,23], glass [24,25], and natural clay [26,27] for radioactive waste stabilization and radiation shielding.

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In this Special Issue, Young Jae Jang, Hye Kwon, Seong Hee Park, Yona Choi, Kum Bae Kim, Dong Wook Kim, Suk Ho Bhang, and Sang Hyoun Choi discuss discarding parts of a medical linear accelerator (linac). The study emphasizes the importance of checking the activity of each part to determine the disposal time according to the clearance level for self-disposal. The clearance level for self-disposal for each radionuclide-activated part was applied by three manufacturers to confirm the timing of self-disposal and to predict when workers are not exposed to radiation during disassembly/disposal. In the interest of establishing the framework for unambiguous safety management standards for the disposal of decommissioned linacs, a qualitative and quantitative study of radionuclides was undertaken using high-purity Germanium (HPGe)-based gamma spectroscopy in addition to the Monte (contribution 1).

Natural mixed waste biomass is an innovative approach to the remediation of contaminated sites. The use of natural mixed waste biomass as a radioisotope biosorbent is a cost-effective approach to the remediation of contaminated sites. Natural mixed waste biomass is an excellent radioisotope biosorbent that can remove radioactive contaminants from soil and water. This approach ensures the safe and sustainable disposal of radioactive waste generated by nuclear facilities. Arwa Abdelhamid, Mogeda Badr, Ramadan Mohamed, and Hosam Saleh explain a sustainable treatment system that uses dry biomass from mixed trash to show synergistic benefits such as high efficiency and cost-effectiveness. The removal of stable and radioisotopes of cobalt and cesium from aqueous solutions was examined in this work using biosorption in dried mixed waste of olive waste and water hyacinth as a low-cost and naturally accessible sorbent. The findings indicate that the natural biomass of mixed garbage is a good biosorbent for the isotopes studied. According to the experimental and mathematical results in this study, a mixed dry waste of water hyacinth and olive waste might be proposed as a sustainable low-cost and effective natural adsorbent material for the efficient remediation of radio or stable cobalt and cesium ions from wastewater. In addition, this method is expected to successfully decontaminate toxic metals and radionuclides in an ecologically benign and sustainable way while significantly lowering wastewater treatment costs (contribution 2).

Natural radioactivity is present in many materials, including granite and ceramic tiles, which contain small amounts of naturally occurring radioactive elements such as ^{232}Th and ^{238}U [28]. These elements emit ionizing radiation in the form of alpha, beta, and gamma rays, which can potentially pose health risks to humans if they are exposed to them for prolonged periods. However, research has shown that the use of mainly granite and ceramic tiles in construction and decoration does not present significant risks to human health. To this effect, Essam Sidique, Sedky Hassan, and Mohammad Mahmoud Dawoud evaluated twenty-three well-known brands of Egyptian commercial granites and ceramic tile samples radiologically using an HPGe detector, consisting of 107 samples of typical materials. The concentrations of radioisotopes were found to be greater in most granite samples compared to the ceramic samples. Additionally, the concentration values of terrestrial radionuclides showed considerable variations in granite and ceramic tile samples obtained from various manufacturers. This is important in distinguishing between the brands under consideration. The concentration of ^{40}K was discovered to be the greatest contribution to the overall concentration for all samples, followed by ^{232}Th and ^{238}U (contribution 3).

A study by Mohamed Ehab, Elsayed Salama, Ahmed Ashour, Mohamed Attallah, and Hosam Saleh investigated the radiation shielding capabilities as well as the optical qualities of a prepared SiO_2-ZnO-Na_2CO_3-H_3BO_3-$BaCO_3$ glass composite with varying amounts of barium carbonate (0–30 mol%). Therefore, fabricated glass is an innovative approach to transparent shielding. The use of fabricated glass for applications requiring transparent shielding can reduce the volume of radioactive waste generated by nuclear facilities. This approach ensures the safe and sustainable disposal of radioactive waste while also providing transparent shielding for various applications (contribution 4).

In a study by Prasoon Raj, Nemeer Padiyath, Natalia Semioshkina, Francois Foulon, Ahmed Alkaabi Gabriele Voigt, and Yacine Addad seven date palm plants in Abu Dhabi were tested. Their root zone soils, fruits, and leaves were sampled and analyzed for gamma-emitting naturally occurring radioactive materials (NORM) radionuclide activity. The soil samples exhibit significant levels of ^{40}K, while the levels of ^{238}U and ^{232}Th are substantially lower. The measured soil radioactivity is below the global average (contribution 5).

The goal of Tarek Sayed and El-Sayed Ahmed's research is to see if gamma irradiation, chitosan, and yeast may help promote the sustainable development of marjoram in the context of organic farming. The primary plot has an abiotic elicitor (15 Gy gamma irradiation), two biotic elicitors (500 ppm chitosan, 0.5% yeast, and a non-elicitor (as control), and two organic fertilizers (20 g/m^2 moringa dry leaves, 20 g/m^2 fulvic acid, and 20 g/m^2 (NPK); the latter is a classic agrochemical). They show strong evidence for the potency of biotic elicitors chitosan > yeast > abiotic, gamma irradiation coupled with organic fertilizers moringa > fulvic acid > traditional agrochemical fertilizer NPK, as reliable CO-friendly solutions, significantly improving marjoram biomass, secondary metabolite production, and quality without the use of agrochemical pesticides and/or microbicides. In addition, chitosan > yeast > gamma irradiation in combination with organic fertilizers outperformed their integration with commercial NPK fertilizer (contribution 6).

Elsayed Salama, Dalal Aloraini, Sara El-Khateeb, and Mohamed Moustafa investigated the thermoluminescence properties of natural rhyolite. Dose response has been evaluated across a large dosage range of 0.5–2000 Gy. The minimum detectable dosage and the rate of thermal fading are calculated. After selecting the optimal read-out conditions, glow curve deconvolution was performed. The overlapping peaks were detected using the repeated initial rise (RIR) approach, and the thermoluminescence characteristics of rhyolite were extracted using a glow curve deconvolution procedure. A linear dose response up to 25 Gy was achieved, followed by supra linearity up to 2000 Gy. The TL properties of rhyolite revealed that it exhibits a linear dose response up to 25 Gy, followed by supra linearity up to 2000 Gy, and a comparatively high fading rate of 57% after two weeks with no further thermal fading seen. There is a low detection limit of around 0.5 Gy and a decent reproducibility of about 4% variance in subsequent measurements. These properties may qualify rhyolite as the sustainable natural material employed in this work for a range of radiation dose assessment applications (contribution 7).

Mohammad Khairul Azhar Abdul Razab, Norazlina Mat Nawi, Fara Hana Mohd Hadzuan, Nor Hakimin Abdullah, Maimanah Muhamad, Rosidah Sunaiwi, Fathirah Ibrahim, Farah Amanina Mohd Zin and An'amt Mohamed Noor confirmed that the high sorption capacity and the ability to coagulate with any reactive elements at molecular structures, such as ^{18}F-FDG, makes it a prime option for alternative radionuclides decontamination. The 'wax tissue' nanolayers and vast surface area have been shown to help graphene oxide (GO) wrap and adsorb radionuclides effectively. The adsorption rate was effective at a slow decay rate of ^{18}F-FDG, where more available free electrons are ready for the adsorption interaction with GO functional groups. Graphene oxide nanoparticles are innovative approaches to the safe and sustainable preparation of radiopharmaceuticals. The use of graphene oxide nanoparticles can ensure the safe and sustainable preparation of radiopharmaceuticals, which may contaminate surface areas due to a spill during their preparation or an accident during their transportation from the laboratory to the treatment room. Graphene oxide nanoparticles show a high absorption affinity towards radionuclides, ensuring the safe and sustainable disposal of radioactive waste (Contribution 8).

Hosam Saleh, Ibrahim Bondouk, Elsayed Salama, Hazem Mahmoud, Khalid Omar, and Heba Esawii adopt environmentally friendly techniques to conserve the environment, such as recycling municipal or industrial waste, where the debris of polyvinyl chloride (PVC) pipes and asphaltene is used as cement additives to improve its mechanical properties while stabilizing radioactive waste resulting from the peaceful uses of nuclear materials, or enhancing its efficiency in radiation protection (Contribution 9).

Chelating agents for uranium mine residues: Chelating agents are innovative approaches to eliminating uranium mine residues. The use of chelating agents can remove uranium from mine residues and prevent soil pollution. This approach ensures the safe and sustainable disposal of radioactive waste generated by uranium mining. Therefore, in their review, Yue You, Junfeng Dou, Yu Xue, Naifu Jin, and Kai Yang discussed the synthesis and application of chelating agents to assist in the phytoremediation of uranium-contaminated soils. The interactions between chelating agents and uranium ions were also demonstrated, in addition to presenting the mechanisms of plant extraction and the effectiveness of different chelating agents for the phytoremediation of soil contaminated with uranium. Furthermore, potential risks associated with chelating agents are discussed. The review also presented the synthesis and application of biodegradable slow-release chelating agents to slow mineral mobilization into the soil while reducing the risk of residual chelating agent leaching into groundwater (contribution 10).

List of Contributions

1. Jae Jang, Y; Hye Kwon, H.; Park, S.H.; Choi, Y.; Kim, K.B.; Kim, D.W.; Bhang, S.H., and Choi, S.H. Analysis of Activated Materials of Disposed Medical Linear Accelerators according to Clearance Level for Self-Disposal.
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3. Sidique, E.; Hassanan, S.H.A. and Dawoud, M.M. Natural Radioactivity Measurements and Radiological Hazards Evaluation for Some Egyptian Granites and Ceramic Tiles.
4. Ehab, M.; Salama, E.; Ashour, A.; Attallah, M. and Saleh, H.M. Optical Properties and Gamma Radiation Shielding Capability of Transparent Barium Borosilicate Glass Composite.
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Short Author Biography

Hosam Saleh is a professor of radioactive waste management at the Radioisotope Department, Atomic Energy Authority, Egypt. He was awarded MSc and Ph.D. degrees in Physical Chemistry from Cairo University. Saleh has more than 25 years of experience in hazardous waste management with an emphasis on treatment and developing new matrixes for the immobilization of these wastes. He is also interested in studying innovative economic and environment-friendly techniques for the management of hazardous and radioactive wastes. He authored many peer-reviewed scientific papers and chapters and served as a Book Editor of several books related to international publishers. He has been selected among the top 2% of scientists in the world according to the Stanford University report for 2020, 2021 and 2022. He is also a reviewer, an Editor in Chief or Associate Editor for different journals as well as a member of the Technical Program Committee for international conferences. He gained the Scientific Encouragement Award from Atomic Energy Authority (2013), Encouragement Prize in Advanced Technical Sciences from the Academy of Scientific Research (2014).