Junior Science Communications
Faculty of Applied Sciences, UiTM Shah Alam
https://journal.uitm.edu.my/ojs/index.php/JSC

E-ISSN 2637-0689
Vol 69 2026

Colloquium on Applied Sciences 2 2025
19-26 January 2026, Faculty of Applied Sciences, UiTM Shah Alam, Malaysia

A Synthesis of Radiation Monitoring Instrument Performance and Application Across Occupational Sectors

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Structured Abstract

Background: Occupational exposure to ionizing radiation remains a major health concern in sectors such as healthcare, industrial radiography, nuclear power, mining, and research. Radiation monitoring instruments are essential for worker protection, regulatory compliance, and dose optimization under the As Low As Reasonably Achievable (ALARA) principle. However, existing studies are often fragmented by sector, instrument type, and application, limiting a comprehensive understanding of current monitoring practices. This scoping review synthesizes evidence on the performance and application of radiation monitoring instruments across occupational sectors.

Methods: A scoping review was conducted to map the literature on conventional and emerging radiation monitoring instruments for occupational radiation protection. Systematic searches were performed in Google Scholar, ScienceDirect, PubMed, and MDPI for peer-reviewed studies published between 2020 and 2026. Eligible studies were screened using predefined criteria and data were extracted through a structured matrix. Findings were synthesized based on instrument type, occupational sector, radiation type, performance characteristics, and regulatory compliance.

Results: A total of 41 studies were included. Passive dosimetry systems, particularly thermoluminescent dosimeters (TLDs) and optically stimulated luminescence (OSL) dosimeters, were the most commonly reported instruments for long-term dose monitoring in healthcare, research, and mining sectors. Active monitoring systems, including electronic personal dosimeters (EPDs), personal alarming radiation dosimeters (PARDs), and wearable Internet of Things (IoT)-based devices, were mainly used in high-risk settings such as interventional radiology and the nuclear industry. Gamma and X-ray radiation were the most frequently monitored types, whereas alpha and neutron radiation monitoring was limited to specialized mining and nuclear research applications. Instrument selection involved balancing sensitivity, real-time monitoring capability, cost-effectiveness, and operational practicality.

Conclusion: This scoping review found that no single radiation monitoring instrument is suitable for all occupational settings, and instrument selection should be based on exposure characteristics, monitoring objectives, and operational requirements.

Keywords: Radiation monitoring instruments, occupational radiation exposure, dosimetry, radiation safety, scoping review

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