CASE STUDY

HEAVY METALS

BY TOXLEARN4EU

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Case study

problem-based learning

Depleted uranium case
by UNSA - INGEB

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1. Introduction

Depleted uranium (DU) is a by-product of the uranium enrichment process, where the isotope uranium-235 is extracted for use in nuclear reactors and weapons. DU is composed primarily of uranium-238 and retains about 60% of the radioactivity of natural uranium. Due to its high density (approximately 19.1 g/cm^3), DU has been widely used in military applications, such as armour-piercing projectiles and tank armour. It is also used in civilian industries for radiation shielding and counterweights in aircraft.

DU is a dense, silvery-white metal that is malleable and chemically reactive. It oxidizes when exposed to air, forming a layer of uranium oxide. While DU is less radioactive than natural uranium, it emits alpha, beta, and gamma radiation at lower levels. Its long half-life (approximately 4.5 billion years for uranium-238) makes it a persistent environmental contaminant. Uranium, including DU, is chemically toxic and primarily affects the kidneys when ingested or inhaled in significant amounts.

Routes of exposure to depleted uranium include inhalation of aerosolized particles, ingestion of soil, water, and food containing DU particles, and dermal contact. In warzones, individuals injured by DU shrapnel may face prolonged exposure.

The health risks of DU exposure arise from both its chemical toxicity and radiological properties. Chemical toxicity of DU presents risk for kidney damage as DU acts as a heavy metal and can cause nephrotoxicity, and impairing kidney function due to the accumulation of uranium compounds. Inhalation of DU dust can lead to lung irritation and potentially chronic respiratory conditions. DU has been shown to damage cellular components, leading to oxidative stress and inflammation. Prolonged exposure to DU's radiation may increase the risk of developing cancer, particularly lung cancer from inhalation of uranium particles. DU's radioactive decay can cause DNA damage, potentially leading to mutagenic effects and congenital defects in exposed populations. DU exposure has been associated with adverse reproductive outcomes, including birth defects in offspring of exposed individuals.

Objective of the study: Evaluating the effects of depleted uranium (DU) in Ukraine assessing environmental contamination, health effects, and risk mitigation strategies.

2. Plan of conducting the evaluation

Step 1. Baseline Data Collection
Historical Analysis
Review available data on DU use, locations of use, and previous studies in Ukraine or similar contexts (e.g., Iraq, Balkans).

Area Mapping
Use satellite imagery, military records, and local reports to identify suspected contamination zones.

Step 2. Stakeholders Involvement
Define potential stakeholders (e.g., government, NGOs, international organizations)

Step 3. Environmental Assessment

Define Sampling Strategy

Determine where and which samples to collect, including both abiotic and biotic components of the ecosystem.

Suggest Relevant Analysis to:

1. Identify isotopes
2. Perform radioactivity measurements
3. Evaluate chemical toxicity

Step 4. Assess ecological impact

Examine the effects on local flora and fauna, particularly species in affected ecosystems (biodiversity effects). Investigate bioaccumulation in plants and animals (food chain effects).

Step 5. Health Impact Assessment

Risk Assessment:

Study DU exposure pathways (e.g., inhalation, ingestion, dermal contact). Evaluate the dose-response relationship between DU exposure levels and health outcomes.

Epidemiological Studies

Suggest a plan of health surveys in communities near contaminated areas and control sites. Think about biomonitoring studies, which samples and tests to use, and relevant disease patterns to analyse.

Step 6. Policy and Risk Mitigation

Remediation Strategies

Propose solutions for the recovery of contaminated areas.

Public Health Measures

Offer medical screening and treatment programs for affected populations.

Regulatory Recommendations

Develop guidelines for DU handling, monitoring, and clean-up.

Step 7. Public Communication and Education

Provide public communication with accessible information on DU risks and safety precautions. Engage media and local organizations to raise awareness.

Step 8. Continuous Monitoring and Follow-Up

Propose long-term monitoring programs to track environmental recovery and health outcomes. Update policies and mitigation strategies based on emerging evidence.

3. Learning outcomes

After this problem based learning, students will be able to:

- search for the data using reliable sources,
- explain the chemical, radiological, and physical properties of DU. manage budget related to a specific activity,
- understand the potential environmental and health impacts of DU contamination,

- apply interdisciplinary integration in understanding the principles of environmental science, toxicology, epidemiology, and policy analysis related to DU,
- explain key pathways of DU contamination in ecosystems and human populations,
- develop evidence-based strategies to mitigate DU contamination and reduce health risks,
- collaborate effectively within interdisciplinary teams, including scientists, policymakers, and local stakeholders,
- present results.

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