

Response to Doctoral (PhD) Dissertation Review Questions

Author:

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Thesis title:

Survey of Naturally Occurring Radionuclides in Soils, Water, and Rice from Artisanal and Small-Scale Gold Mining Affected Areas in Ghana

Reviewer:

Dr Begy Robert-Csaba
(Associate Professor)

I would like to sincerely thank Dr Begy Robert-Csaba for his conscientious work and valued time in reviewing my thesis, and for his appreciation of my work. I would like to give the following answers to his numbered questions.

1. What are the opportunities for mitigating the environmental and human impact of the illegal mining activities, preferably listing some potential legal, economic and technological options?

From a legal perspective, there is the need to tighten the enforcement of current regulations such as the Minerals and Mining Act 2006 and improve the oversight by institutions such as the Environmental Protection Agency (EPA) and the Nuclear Regulatory Authority (NRA) in Ghana. However, beyond the enforcement, there is vital potential to formalise artisanal and small-scale mining. Also, by simplifying the licensing process and establishing community mining zones there is the chance where illegal mining operations can be brought under regulated system where environmental and safety standards can be maintained. Furthermore, enforcement of land reclamation regulations and community participation in environmental governance can greatly prevent long-term ecological damage.

Illegal mining in Ghana is primarily driven by poverty and lack of alternative livelihood options from an economic perspective and is driven further by the continuously growing price of gold. Therefore, alternative sources of income such as agriculture, vocational training and small firm development can assist minimise the dependence on illegal mining. Also, access to financial support, introduction of incentives for responsible mining techniques and promotion of gold tracking program can enable miners to transit into legal mining while maintaining the economic benefits of gold.

Technological and scientific interventions are also very significant, especially in terms of risk assessment and reduction of environmental contamination. Use of mercury free gold extraction technologies can greatly reduce poisonous pollution and environmental monitoring by gamma spectrometry can be used to evaluate the naturally occurring radionuclides in soils, water and food crops. Complementary tools such as remote sensing and GIS can help identify areas of illegal

mining and follow land degradation in real time. Furthermore, socio-economic cost-effective remediation technologies such as artificial wetlands, adsorption filters and sedimentation systems can eliminate heavy metals and radionuclides from polluted water bodies, while phytoremediation can assist in the regeneration of polluted ecosystems.

2. What is the opinion of the candidate on the validity of the LNT model and based on that and the international literature would the candidate say that the current Ghanaian legal framework for assessing the impact of mining is too loose, matches international trends or is too strict?


The Linear No-Threshold model (LNT) is the most common used framework for radiological protection, which assumes that any increase in radiation dose increases the risk in a proportional manner and that there is no safe threshold. Although the validity of the LNT model at very low doses, is debatable in the scientific community, leading international agencies like the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA) still endorse it. For the purposes of my study which deals with possible chronic and low-level exposures through environmental pathways such as soil, water and food, the validity of the LNT model in my opinion would be considered as a conservative and appropriate tool for estimating potential radiological risks and ensuring such risks are not underestimated.

The existing legal framework such as the Minerals and Mining Act 2006 and regulatory oversight by the EPA and the NRA provide a sound foundation for general environmental protection for the regulatory framework in Ghana. However, in comparison to international best practices established by the ICRP and IAEA, there is insufficient explicit incorporation of radiological risk assessment, especially with respect to naturally occurring radionuclides in mining-affected environments. Routine radionuclide monitoring, ingestion dose assessment and the use of LNT-based risk modelling are not incorporated in a systematic way in environmental impact assessments. In 2021/2022, my colleagues at the NRA and I developed a regulation to close this gap, but it has not yet been taken up by the lawmakers (politicians).

Therefore, in my opinion, while Ghana's legal framework broadly aligns with global environmental management trends, it is relatively too loose in terms of radiological protection. Strengthening the integration of radiological assessment, especially in mining activities would improve its alignment with international standards and enhance the protection of both the environment and public health.

I thank Dr Begy Robert-Csaba once again for reviewing my thesis and humbly request for the acceptance of my answers.

Veszprém, 2026 May 4


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