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Risk Assessment on Explosives and Heavy Metals at a Military Gunnery Range

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ABSTRACT

Risk assessment on pollutants and contaminated territories has become an essential procedure for managing hazardous substance and remediation strategies. Alike areas polluted by industrial activities, on maneuver sites, explosive compounds including 2,4,6-trinitrotoluene (TNT), hexahydro-1,3,5-trinitro-1,3,5-triazine (Royal Demolition Explosive, RDX) and octahydro-1,3,5,7-tetranitro,-1,3,5,7-tetrazocine (High Melting Explosive, HMX), as well as heavy metals contaminate soil and surface water, and are possibly be leached into groundwater. Nevertheless, even the environmental standards of these explosives as contaminants are not set in many countries including Korea. This makes the risk assessment of explosives and related heavy metals in military gunnery range more important and valuable. The aim of this research is to assess the risks of three explosive contaminants (i.e., TNT, RDX, HMX) and three heavy metals (i.e., Cd, Cu, Pb) which are expected to leach from a contaminated gunnery range site, to improve the remediation and management strategy.

In practicing the risk assessment of the target contaminated site, we selected effective and reasonable exposure pathways to avoid any overestimation of the risk, and used conservative default values to prevent underestimation of the risk as well. The carcinogenic and non-carcinogenic risks of the six contaminants were calculated by API's Decision Support System for Exposure and Risk Assessment (DSS). The assumptions for the risk assessment process are as follows:

1. The risk acceptors (human beings) inhabit in the target site (gunnery range),
2. All of their farming and stockbreeding works also occur in the site (gunnery range),

3. The gunnery range has been operated for a sufficient duration on the site, and therefore the distributions of contaminants has reached equilibrium,
4. Chemical or biological degradation of the contaminants are negligible.

A project to construct a flood controlling reservoir near the gunnery range is in progress, and detailed concentration data of the contaminants have been obtained for environmental impact assessment of the construction. The soil type of the site is surveyed to be mainly silty clay and always slightly wet on the surface due to insufficient drainage.

In the area designated as Ac, where craters have been formed by explosions and impacts, the non-carcinogenic risks of TNT and Cd show a value slightly larger than 1. For RDX, the non-carcinogenic risk calculates over 50 in Ac, and more than 1 in every area except area C. The non-carcinogenic risk of the total gunnery range calculates to a significantly high value of 62.5. However, carcinogenicity of Cd in the site is estimated to be about 0.1%, and for Pb, the carcinogenic probability is lesser to about 0.05%.

The assessment of the target contaminated site concludes that remediation strategy concerning TNT, RDX and *etc.* are highly necessary on areas Ac, A and B, where non-carcinogenic risks are considerable. The carcinogenic risk has also exceeded the general target remediation level of $10^{-4} \sim 10^{-6}$ on the site. However, it is assumed that the carcinogenic risk will drop to an adequate level, while proceeding remediation methods focused on controlling the non-carcinogenic risks. For more accurate risk assessment, specific estimation of condition shifts after the construction of the reservoir is required, and more over, effects of the contaminants to the ecosystem is also necessary to be evaluated.

Key words: Military Gunnery Range, Risk assessment, Explosives, Heavy metals