

Insights from a specialist NATO meeting, AVT-394: Advancing Environmental Sustainability in Military Training

By Sally Webb

The NATO specialist meeting, AVT-394, held in Koblenz, Germany in October 2024, gathered experts from NATO countries, including Canada, Germany, the UK, Finland, Denmark, Switzerland and the USA, to evaluate advancements in water sampling, monitoring, and remediation techniques aimed at mitigating munitions-related contamination in live-firing ranges. As a current PhD student at the UK Defence Academy, Cranfield University, funded by Cranfield University and the Ministry of Defence and Cranfield University under the CBRN educational program and supervised by Professor Tracey Temple and Professor Frederic Coulon, I had the opportunity to attend and present at the specialist meeting. My research focuses on representative sampling methods for hazardous chemicals released by industry, warfare or terrorist acts. My background in Forensic science and analysis has enabled me to build a broad scientific basis, thus aiding me in understanding diverse scientific approaches. Presenting a paper on my current research explaining the importance of a well thought through sampling plan for post-blast water sampling, was a great and invaluable experience. This opportunity allowed me to network with experienced industry peers and engage in valuable knowledge exchange.

The meeting was part of the 54th AVT Panel Business Meeting (PBM) and aimed to promote military live-fire range sustainability. Contamination from munitions constituents such as heavy metals, explosives residues, and propellants, which have migrated to surface and groundwater in their respective training areas, has been documented by several NATO nations. Understanding contaminant migration is crucial to minimising adverse effects and preventing potential range closures. The goal of the meeting was to bring experts in water sampling and monitoring together with specialists experienced in remediation and control techniques. The meeting provided a platform for transferring knowledge gained throughout the NATO community to the broader defence community. Spanning three days and seven sessions, the meeting kicked off with a keynote address, followed by presentations on water monitoring strategies.

Keynote Address: A German Perspective

LTG Hanjo Neue, the first keynote speaker, provided a German military perspective on environmental issues associated with live firing and training ranges. He discussed Germany's regulatory framework, which prohibits environmental pollution but allows exemptions for military operations where compliance is impractical. An emphasis was placed on the separation of regulatory authority and operational responsibility, aiming to streamline environmental management for training ranges. He also introduced Germany's efforts to map and classify training ranges under the European NATURA 2000 biodiversity framework, which had previously excluded military areas. To bring his talk to a close he outlined a staged vulnerability analysis process to address contamination, including risk assessments, hydrogeological studies, and remediation measures such as water control systems and wastewater treatment. The keynote highlighted the importance of departmental cooperation to facilitate the management and mitigation of environmental pollution. This is the case in many industries including CBRN related incidents, where cooperation stands at the forefront.

Water Monitoring Strategies

Monday started off with session one under the umbrella of water monitoring strategies. The evolution of monitoring programs, the implementation of environmental solutions, and the

development of new tools were discussed. Presentations featured the Canadian Armed Forces' environmental risk management program, which uses a passive approach in combination with monitoring of receptors for early warning signs. Long-term impacts on water quality, particularly regarding heavy metals, were discussed. A spatial data model for mapping flow routes in Range and Training Areas was introduced to improve water protection planning. Underscoring the need for robust sampling techniques and quality control, Johnson's work showed large fluctuations over time in sampling of surface waters as well as a need to reanalysis of samples due to laboratory error. The presentations from this session were from Canadian, Finish and Norwegian Defence. Surprising to me was the passive approach by the Canadian Armed Forces to monitor the environmental risk through use of an automated risk evaluation tool.

Water Sampling and Hydrology

Session 2 delved into interpreting water sampling data for environmental assessments. The second Keynote address was given by Sonia Thiboutot, who presented the history of US-Canada collaboration on environmental sustainability, especially in hydrology, with efforts dating back to the 1980s addressing contamination risks. Larson from the Danish Defence Estates Agency shared data from a century-old Range and Training Area, showing minimal impact on local waterways outside the training area. This is due to the munitions being contained in marshland and sandy soils. Lapointe et al. highlighted challenges in arctic conditions, where slower degradation of munition components and thus increased toxicity necessitate caution in expanding training activities in these environmental conditions. An interesting point to take away is that it took over 10 years to convince military owners of the risk of contamination from munition constituents even though scientific evidence was present. Therefore, scientific research has value past the inception of the ideas and knowledge generated but can affect significant change later on.

Underwater Munitions Sites

Session 3 focused on underwater munitions sites, which have historically been used to dump unwanted munitions. These sites are now under growing scrutiny for potential health and environmental risks. The inception of the 'Maritime Underwater Munitions' module for the Explosives Ordnance Engineering MSc run at Shrivenham, shows the importance of spreading awareness and teaching about these issues to the new generation of Explosive Engineers. While most underwater sampling has shown low contamination levels, questions remain about the adequacy of current sampling methods. A Swiss representative of Amasuisse real Estate Kaiser discussed concerns about munition contamination in Swiss lakes, while American research under Lotufo highlighted high contaminant concentrations near the source, emphasising the need for further investigation. The dumping of ammunition has been a significant issue and is investigated in the UK, Germany and Switzerland to name a few. Three papers explored sampling methods and mitigation techniques, with Lotufo documenting PICIS (polar organic chemical integrative samplers) as a reliable and sensitive method in time varying conditions. Passive samplers have been utilised in studies relating to wastewater as well and have wider applications in other research areas. My own research demonstrated representative sampling poses a challenge as explosive residues in water present a heterogeneous contamination pattern. Traditional grab sampling (GS), while simple and cost-effective, often produces highly variable results due to its limited spatial and temporal scope. Composite sampling (CS) aims to address these limitations by pooling multiple samples, but it may dilute trace contamination, leading to

reduced detection sensitivity. The 3D-Multi-Increment-Sampling (MIS) method, although more complex, systematically captures contamination across spatial dimensions, enhancing representativeness. This was shown in an in-situ experiment where six pipe bombs—three using high-order detonations and three using low-order deflagrations—in 1,000-liter water-filled intermediate bulk containers (IBCs) were detonated. Post-detonation samples were collected using GS, CS, and 3D-MIS methods to evaluate their efficacy. High-order detonations yielded low residual TNT, while low-order deflagrations left significantly higher concentrations. Quality control measures, including field blanks and duplicate samples, were implemented to ensure accuracy. It was found that GS provided the fastest results but exhibited high variability. It was most effective for preliminary hazard mapping but limited in reliability for low-concentration residues.

CS on the other hand reduced analytical costs and time but underperformed at detecting low-level contamination. Finally, 3D-MIS yielded the highest recovery rates and effectively captured heterogeneous contamination patterns. However, it was the most resource-intensive method, requiring extensive planning and equipment.

This study highlights the importance of selecting appropriate sampling methodologies based on specific objectives and constraints. The remaining talks focused on remediation efforts utilising activated carbon (AC) and biochar. Both British research from Cranfield University under Perisco et al. and Finish research under Kopponen tested activated carbon (AC) and biochar for removing TNT from water, finding both materials effective, with ground rice husk emerging as a sustainable alternative to AC. While Persico et al. achieved significant remediation of contaminated water in the laboratory, Kopponen managed to treat TNT and RDX contaminated ground water from a Finish training range with 95% reductions of contamination at a total cost of 1€/L. The real-world applications for these remediation measures are significant aiding the clean-up of leached munition constituents in groundwater and water bodies but may also have wider applications for other hazardous compounds.

Active Source Zone Remediation

Session 5 addressed the Issues with the treatment of contaminated water on the range as infrastructure such as electric power is not accessible, hence all remediation must be driven by gravity. Finish Defence Research presented by Pihkala discussed methods to mitigate runoff from shotgun ranges, such as bioremediation with willow and using the marsh surface as a biofilter. Lead pellets scattered on the surface and corroding are an issue as lead is easily mobilised, so valuable data can be gathered from this study for wider application on civilian ranges for example. University of Finland's Väisänen et al. introduced a novel 3D printed polypropylene 4D Scavenger filter filled with ion exchange resins for metal removal. 90% of lead and 60% of copper were successfully removed from contaminated water. National Defence Canada's Cloutier presented back-stop systems for mitigating heavy metals and energetics at small arms ranges. However, a drawback here is the required maintenance of these backstops. The session stressed the importance of integrated, cost-effective systems for managing contaminants across different ranges in the field.

Perchlorate and Climate Change Challenges

Day three set off with the last session led by Canadian research focusing on the environmental impact of ammunition containing perchlorate and the risks associated with its disposal. Open detonation of rocket motors has left significant unburned perchlorate, which is highly soluble in

water and poses threats to drinking water as well as ecosystems. Studies demonstrated that improper disposal methods led to groundwater contamination. Key lessons emphasised the importance of proper combustion and understanding local geology and hydrology to manage risks. Munitions containing perchlorate are increasingly destroyed as their shelf life is coming to an end, thus increasing the risk of contamination as evidenced. Therefore, other disposal methods or the mitigation of perchlorate leeching into the environment are fundamental concerns in current research.

Finally, the meeting ended with a panel discussion on the effects of climate change on military ranges. In Norway, increased precipitation is expected to cause more flooding and erosion, while milder winters will lead to greater damage during exercises. Similar trends were noted in Switzerland and the Netherlands, with rising sea levels and increased flooding risks for the latter. In Canada, warmer temperatures and droughts will increase the risk of thawing and thus munition release, while in the USA, climate uncertainty presents challenges related to leaching contaminants, more extreme weather events, and flooding of military facilities. These emerging issues show the importance of exchanging mitigation measures across countries to be prepared for future challenges.

Conclusion

The NATO specialist meeting highlighted the importance of innovative water sampling and remediation techniques in ensuring the sustainability of military training ranges while minimising environmental impact. By adopting these measures, the long-term viability of live-firing ranges and protection of surrounding ecosystems can be achieved. Collaboration and knowledge-sharing among nations remains crucial for advancing the science and technology of sustainable range operations, and future efforts should focus on integrating new technologies while proactively managing risk. The NATO research community gathers for these specialist meetings frequently, facilitating the exchange of specialist research and allowing for further generation of knowledge relating to many areas of concern, not only limited to environmental challenges with live firing ranges. The meeting emphasised the importance of robust sampling methodologies and quality control in environmental monitoring, directly applicable principles to the focus of my PhD. Presentations on the mitigation of munition constituents, such as heavy metals and explosives, closely mirrored the challenges I face in quantifying hazardous chemical agents in diverse environmental settings. Thus, the methodologies discussed aligned with the challenges of my own research and provide transferable insights into developing sampling plans tailored for high-risk scenarios, such as chemical attacks and industrial chemical spills.



DSPACE

<https://dspace.org/>

Insights from a specialist NATO meeting, AVT-394: advancing environmental sustainability in military training

Webb, Sally

2025-03-01

Institute of Explosives Engineers

https://issuu.com/iexpe/docs/explosive_engineering_issue_1_2025

Webb SL. (2025) Insights from a specialist NATO meeting, AVT-394: advancing environmental sustainability in military training. Explosives Engineering, Volume 2025, Issue 1, March 2025, pp. 16-18