

Open Burning of Excess Gun Propellant : Investigation of the Production of Dioxins and Furans as Combustion By-Products

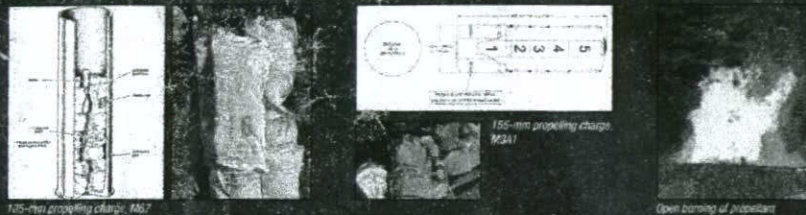
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Context

- Live fire training is an important part of military activities to ensure a high degree of preparedness for any potential mission
- Ranges and training areas are contaminated with various products due to military training. Among the contaminants found on ranges, dioxins (PCDD) and furans (PCDF) were identified at various locations, their source still unidentified
- In Canada, the burning of excess propellant was suspected to lead to the accumulation of dioxins and furans; this study was conducted to determine if they are produced in this context

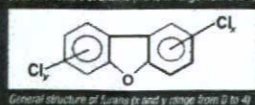
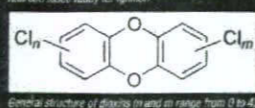
Burning of propellant

- The propellant for large caliber ammunitions are incremental and the number of bags are adjusted depending of the required firing distance
- The actual practice is to dispose of the excess propellant bags by open burning
- The burning does not lead to complete combustion
- Ignition is carried out using a railroad fusee that contains perchlorate



Dioxins and furans

- Families of highly toxic compounds
- Source is very difficult to determine
- By-products of the combustion of many compounds
- Rarely encountered individually in the environment, the way to compare the toxicity of samples is by using a toxic equivalent quantity (TEQ)
- Regulations for :
 - concentration in soils (CCME : 4 ng TEQ/kg)
 - concentration in water (drinking water Quebec province : 0.015 ng TEQ/L, US EPA : 0.03 ng TEQ/L)
 - daily intake by humans (10 pg TEQ/kg body weight)

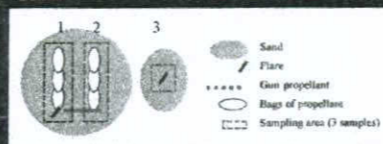


$$(1) \text{ Total TEQ} = \sum_{i=1}^n (C_i \times \text{TEF}_i)$$

TEQ :	Toxic equivalent quantity to the representation of the mixture of congeners, expressed in equivalent of 2,3,7,8-TCDF
n :	number of congeners
C _i :	concentration of congener i
TEF _i :	Toxic equivalency factor for the congeners

Experimental setup

Sand



Schematic of the setup on sand



Setup for the flare trial: a) before, b) after the combustion

Steel Plates



Setup for the table trial



Table after turning and sampling positions

Analysis

- Samples were sent to a private company (Biolab, Thetford Mines, Quebec) for analysis
- Liquid extraction with toluene in a Soxhlet apparatus, followed by purification and concentration
- Analysis by GC-MS
- The method detection limit is 0.1 pg/g for each of the congeners
- The concentrations were transformed into the TEQ by use of Equation 1

Results

Sand

- Small quantities detected probably due to the dilution induced by the sand collected with the ashes

- Overall, the results of the flare trial on sand are considered as non-conclusive, and the use of the stainless steel table for the burning was the best approach as for sample collection

Sample #	Description	TEQ (pg/g)
1	Propellant + flare residues + steel	0.0006
2	Propellant residues + steel	0.0009
3	Flare residues + steel	0.0006

Steel

- The sampling was carried directly on steel avoids any dilution of the residues

- Concentration of dioxins and furans (reported as TEQ) were higher in the area near the flare (5.18202 pg/g), than in the area where there was no contact with it (middle of the table, 0.06875 pg/g)

- The residues of the flare itself showed intermediate value (0.33743 pg/g)

- The presence of the flare clearly was accountable for the production of dioxins and furans

- No replicate was performed for this trial, these values should be taken only as indications that the flares produce dioxins and furans during a combustion with gun propellant, and should not be used for any further calculation

Sample #	Description	TEQ (pg/g)
1	Flare residues	0.33743
2	Propellant residues near flare	5.18202
3	Middle of table (noncontact residues)	0.06875

Conclusion

- The open burning of excess gun propellant produces dioxins and furans due to the presence of a railroad fusee as the ignition source
- From other trials, we know that this production is worse when the burning is performed on snow cover due to a less complete combustion
- The procedure should be modified in order to reduce or avoid the production of dioxins and furans:
 - Remove the chlorine source, i.e. the railroad fusee that contains perchlorate. Ignition could be done using a chlorine-free device and that can be delayed to provide an acceptable safety time delay
 - The procedural manual for Destruction of duds and misfired ammunition on CF ranges and training areas should be modified to account for the findings in this report
 - Other procedures for the ignition of the burning should be investigated
- The open burning of excess gun propellant produces other residues that are considered hazardous for the environment (energetic materials, metals); the whole concept of open burning on the ground should be revised to avoid contamination of surrounding soils

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