POSOUZENÍ SEKUNDÁRNÍ KONTAMINACE PO UPLATNĚNÍ SOUČASNÝCH DEKONTAMINAČNÍCH POSTUPŮ

ASSESMENT OF SECONDARY CONTAMINATION AFTER DEPLOYMENT OF CURRENT DECONTAMINATION PROCEDURES

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Abstrakt

Proces dekontaminace, odstraňování chemických a biologických rizik (CB) z povrchů, budov, vozidel a venkovních prostorů je klíčovým krokem k úspěšné reakci na útok zahrnující CB látky. Základním požadavkem pro dekontaminaci je, aby jako proces byla rychlá, extrémně důkladná při zachování její ekologické šetrnosti s cílem dosáhnout maximální úrovně její účinnosti v souvislosti s otázkou zbytkové kontaminace a zbytkového zdravotního rizika, které z toho vyplývá. I když je známa úroveň zbytkové kontaminace po dekontaminaci, není triviální jednoznačně stanovit zdravotní rizika s ní spojená. Cílem projektu RACED bylo proto navrhnout nástroj pro řízení rizik, který by umožnil oprávněným osobám racionálně a důvěrně deklarovat dostatečnou účinnost dekontaminačního procesu nebo potřeb pro opětovné provedení dekontaminačního kroku nebo úpravu postupu z hlediska dekontaminačních prostředků, času nebo její kvality.

Klíčová slova: *CB dekontaminace, zbytková kontaminace, posouzení zdravotního rizika*

Abstract

The process of decontamination, removing chemical and biological (CB) hazards from surfaces, buildings, vehicles and outdoor areas, is a key step in successful response to an attack involving CB agents. The basic requirement for the process of decontamination is to be quick, extremely thorough and environmentally inert while trying to reach the maximum level of decontamination process efficiency related to the question of residual contamination and remaining health risk arising therefrom. Even if residual contamination is known, it is not possible to relate unambiguously that to the remaining health hazard. The aim of the RACED project was to propose a risk management tool that allowed the operational decision maker to declare rationally and confidently sufficient efficacy of the decontamination process or needs for redo the decontamination step, or adjust the procedure in terms of decontamination means, time or thoroughness.

Key words: *CB decontamination, residual contamination, health risk assessment*

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1. Introduction

CB Decontamination has to be quick, thorough and environmentally inert whilst reaching maximum decontamination efficacy resulting in minimal residual agent and no health hazards. Achieving this can be challenging enough in a controlled environment like the laboratory let alone under operational conditions in the field. RACED aimed to address a number of aspects related to residuals after decontamination and the potential health hazard of these. Experimental work looked at chemical and biological residuals on three different surfaces: CARC, rubber and plastic under different environmental conditions. RACED also investigated how much of these residuals could subsequently transfer via evaporation, reaerosolisation and by direct contact (via gloves and skin) in addition to collating information on the published health hazard (Lethal Dose LD_{50}) for a wide range of chemical and biological agents in animal models.

2. Risk assessment approach

There is a wide range of risk assessment and risk management methodologies used by different civilian and defence agencies, nationally and internationally across multiple disciplines. RACED attempted to develop a generic approach for dealing with chemical and biological residuals and the risk management of these. However whilst many risk aspects are generic regardless of contamination type, specific risk assessment for each agent can require a more tailored approach. RACED adopted the bow-tie approach for the generic risk analysis tool. A chemical residual assessment tool (available in Matlab) was developed using a statistical approach based on a limited number of variables to evaluate the decontamination efficacy on different substrate surfaces given that time and temperature were not found to be significant variables in this model. Another descriptive model was developed to assess potential contact transfer and evaporation, which are affected by temperature, surface area and length of time exposed but were not affected by the initial concentration level. The results from this later model can be used to evaluate potential exposure dose and thus health hazard and set limits for safe exposure levels. These models can be used as a starting point for risk management to assess if an asset is clean enough or not. However the hazard assessment is not just restricted to physicochemical properties of the agent and the surface upon which it is found. The bow tie model also has to take into account the type and activity of the forces deployed, information about the chemical attack and decontamination measures, any additional post decontamination measured employed and then a applies a hazard calculation for the post decontamination situation. Using the RACED risk models and ALOHA software the agent dispersion and concentrations post decontamination can be predicted and combined with acute exposure guideline levels (AEGL) data to show health hazard areas.

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Table 1: Biological agents, substrate materials, and decontamination solutions investigated in RACED

Biological agents	☐ *Bacillus cereus* ☐ *Bacillus anthracis* ☐ *Bacillus thuringiensis* ☐ MS2
Substrate material coupons	☐ CARC ☐ Rubber ☐ Hard plastic ☐ Glass
Decontamination solutions	☐ Sodium hypochlorite (NaClO) ☐ Peracetic Acid ☐ No decontamination solution

The information used in the chemical hazard assessment tools were not however directly transferable to the biological agent scenarios. Therefore a slightly different approach was used building upon a slightly different risk assessment method. Contact transfer as a means of biological agent transmission is limited unless the person exposed has an open wound or manages to transfer the agent to a mucous membrane via touch or ingestion. The reaerosolisation studies were unable to demonstrate any significant reaerosolisation, even with storm force winds on the CARC panels, suggesting that this route of transfer for the bacterial spores tested is also limited. Contact transfer did occur but with different levels of efficiency for the four agents tested and the three surfaces tested. Contact transfer was tested using both a glove as well as pig skin. The animal studies used to evaluate the LD_{50} for inhalation and other modes of transmission varied widely depending on not only the type of agent but also on the strain of the agent as well as mode of transmission. Given the lack of reaerosolisation in our experimental set up and disparities in the information regarding inhalation lethal dose 50 (LD_{50}) and the LD_{50} from direct contact we were unable to create a generic method similar to the approach used for the chemical agents.

Table 2: Chemical agents, substrate materials, and decontamination solutions investigated in RACED

Chemical agents	☐ HD – Sulfur mustard ☐ GD – Soman ☐ VX ☐ TDI – Toluene-2,4-diisocyanate (TIC)
Substrate material coupons	☐ CARC ☐ Rubber ☐ Hard plastic ☐ Glass
Decontamination solutions	☐ Sodium hypochlorite (NaClO) ☐ GDS 2000 (Kärcher) ☐ No decontamination solution

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The practical decontamination exercises highlighted many of the issues that can be encountered when carrying out decontamination. The results show that whilst indoor decontamination was successful for B agents, the outdoor decontamination of a large vehicle was problematic. The risk assessment method shows which areas of the vehicle remained a health hazard post decontamination compared to giving a green light for successful decontamination.

Decontamination efficacy is difficult to measure in "real-life" situations with cracks, crevices and other difficult to reach areas posing a particular hazard. We need a more detailed geometrical model of the surfaces to be decontaminated to ensure correct risk modelling as well as a systematic method of applying the decontaminant that can minimise human error and ensure even distribution of the decontaminant across the equipment being used. Future work on CB risk management should focus on harmonising and standardising the risk assessment process, developing realistic scenarios using standards templates, further developing test panels that can be used as positive controls during decontamination efforts to ascertain decontamination efficacy. The use of positive controls would allow decontamination of difficult to reach areas to be assessed with empirical data and strengthen decision making processes.

3. Can we use a common strategy to manage the risk of residual CB levels?

The results from the RACED project, whilst based on a limited number of agents under a limited number of test conditions, show that with further work, modelling of residual risk post decontamination may be possible. However a large number of gaps still exist that require attention before a complete model can be finalised, tested and validated under a wider range of experimental conditions. These type of risk assessment and management tools are not only relevant for military purposes but are also needed with regard to other contamination incidents or as disease control measures; for example border inspections and decontamination to prevent the spread of disease being shipped from endemic countries to countries free from infection. As more science becomes available, better tools for detection and identification are developed and new data regarding aerosol biology and impact on human health is published, we will be able to develop more nuanced models that can evaluate and predict decontamination requirements and health hazards. For now we need to focus on risk, threat and vulnerability assessments and further develop our hazard detection and identification technologies.

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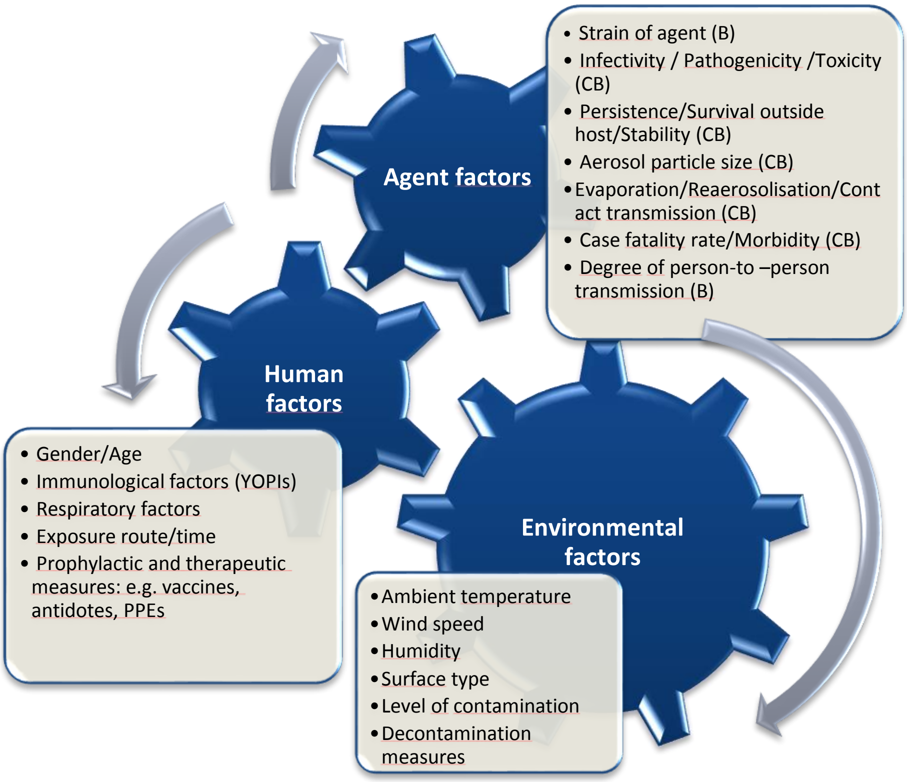

Figure 1: Conceptual model showing the multiple variables that can affect the risk

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