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The Flash Environmental Assessment Tool: Worldwide first aid for chemical accidents response, pro action, prevention and preparedness

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ABSTRACT

The United Nations response mechanism to environmental emergencies requested a tool to support disaster assessment and coordination actions by United Nations Disaster Assessment and Coordination (UNDAC) teams. The tool should support on-site decision making when substantial chemical emissions affect human health directly or via the environment and should be suitable for prioritizing impact reduction management options under challenging conditions worldwide. To answer this need, the Flash Environmental Assessment Tool (FEAT) was developed and the scientific and practical underpinning and application of this tool are described in this paper. FEAT consists of a printed decision framework and lookup tables, generated by combining the scientific data on chemicals, exposure pathways and vulnerabilities with the pragmatic needs of emergency field teams. Application of the tool yields information that can help prioritize impact reduction measures. The first years of use illustrated the usefulness of the tool as well as suggesting additional uses and improvements. An additional use is application of the back-office tool (Hazard Identification Tool, HIT), the results of which aid decision-making by the authorities of affected countries and the preparation of field teams for on-site deployment. Another extra use is in disaster pro action and prevention. In this case, the application of the tool supports safe land-use planning and improved technical design of chemical facilities. UNDAC teams are trained to use the tool after large-scale sudden onset natural disasters.

1. Introduction

> "If I had eight hours to chop down a tree, I'd spend six hours sharpening my ax."
>
> [Abraham Lincoln, 16th president of the U.S.A.]

Chemical incidents still occur frequently, both in the aftermath of natural disasters (so-called natural-hazard triggered technological — NaTech incidents) and due to human error and technical failures (Krausman et al., 2011; Krausmann and Cruz, 2013; Srinivas and Nakagawa, 2008; Young et al., 2004; Zio and Aven, 2013). Major incidents such as those of Bhopal (India, 1984) and Seveso (Italy, 1976) are well known, due to serious human health impacts. But long-lasting impacts on humans, husbandry and nature became apparent too (Bertazzi et al., 1998; Broughton, 2005; Fanelli et al., 1980;

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Walsh, 1977), stressing the need to make comprehensive assessments that include vital ecosystem services (UN, 2003). A recent development in managing such incidents has been the development and use of a novel comprehensive 'first aid' tool. This paper describes the tool and evaluates its initial applications after chemical incidents around the globe.

A main challenge in international incident management was identified and discussed in the aftermath of the 2004 Indian Ocean tsunami (Indonesian Ministry of the Environment, 2005; JEU, 2007d, 2007e). In this case, an emergency field team member (SvD) situated in Banda Aceh frequently needed chemical hazard information from a back-office (DdZ). Although authorities have formulated preventive regulations as well as response mechanisms for various regions (EC, 1996; U.S. DOC., 2010; UNECE, 1992, 2008, 2013), most incidents are complex (involving emissions of multiple chemicals), so that international emergency teams need to quickly prioritize impact reduction actions, often in difficult conditions (Katoch, 2006). This holds e.g. for globally operating United Nations Disaster Assessment and Coordination teams (UNDAC, see http://www.unocha.org/what-we-do/coordination-tools/undac/overview). Such teams are not necessarily populated with chemical incident experts. This may not only imply personal hazards for them, but it also implies that the identification of priority impact reduction measures is seriously delayed — and time is of the essence to prevent and reduce impacts. Cumulated experiences with NaTech incidents around the globe thus resulted in a call for a novel and comprehensive tool, which should enable quick priority setting amongst possible impact reduction actions of chemical incidents under large uncertainties (Barrett et al., 2007; Cormier, 2008; Zio and Aven, 2013). A parable, in JEU (2009a)[2], shows that good quick priority decisions can be taken when hazard information is combined with the judgement capabilities that can be expected from trained field team members. In reply to the challenge, a comprehensive tool for quick priority assessments was made by the combination of science-based impact analyses of NaTech scenarios with the practical needs of field teams.

We describe the scientific and practical rationales, the printed format, the confirmation, the use and the initial evaluation of a 'first aid' tool that was developed to address the needs summarized above. The tool is called the "*Flash Environmental Assessment Tool*" (FEAT). Dijkens and Westerbeek (2012) describe the broader global emergency preparedness and response context of this tool. The objectives of this paper are (1) to summarize the scientific rationales of FEAT, (2) to evaluate the confirmation status of FEAT outcomes and initial experiences of users since its inception as prototype, and eventually (3) to derive possible improvements. A key option for improvement which is discussed in view of the (positive) evaluations of the tool (under 2) are additional applications, namely: for safe spatial planning around- and for safe technical design of facilities with hazardous chemicals. This would help in preventing hazards of facilities to develop into incidents and undesired impacts. These are additional uses that are fully in line with Lincoln's citation in the article header.

2. Scientific and pragmatic rationales of the tool

2.1. Format, aims and limitations

FEAT is a 'first aid' impact assessment and response prioritization tool, aimed to be used immediately after a chemical incident anywhere in the world. It consists of decision trees and lookup tables that are designed to support prioritization of impact reduction measures. The tool is available as a printed User's Guide in English, Spanish and French (JEU, 2009a,b,c; Van Dijk et al., 2009). Contextual information is presented in http://www.unocha.org/what-we-do/coordination-tools/environmental-emergencies/resources.

A printed tool has limitations to remain operational for field teams. The design was therefore focused on highest-hazard situations. Further, the tool has a use limitation. The design aim was to inform assessment teams on (potential) priority impacts, but *not* to define the impact reduction actions the team should take. Those can generally consist of (a) actions to isolate or limit the source (emission reduction), (b) block or limit the pathway (environmental dispersion) and/or (c) remove or isolate the receptor (evacuation). Which (combination of) action(s) can be taken is however site-dependent. For example, a stream of toxic fluid can be limited when a bulldozer would block a toxic fluid stream from reaching a pathway to further exposure (e.g., a stream) and/or a valued receptor, e.g., a water body used as drinking water resource. *Which* action can be taken is beyond the scope of the tool, but *that* quick action matters can be easily shown by comparison of two incidents. The incident at Sandoz (1986, Switzerland) caused major impacts in the river Rhine, since sewer systems capturing fire extinguishing water and chemicals were not effectively closed (Giger, 2009), whilst a similar incident at Chemie-Pack (2011, the Netherlands) induced little impacts on the Hollandsch Diep river due to measures blocking chemical leaks (RIVM, 2011a,b; Wintersen et al., 2011).

2.2. Design principles

Due to experiences with NaTech incidents, the focus of the tool was on three assessment endpoints: impacts on humans, impacts on livelihoods, ecosystem services and nature, and the potential for long-term impacts on those. The latter was considered relevant given that persistent chemicals may be involved in incidents.

The design of the tool is based on the combination of science-based risk assessment of a suite of incident scenarios and practice-oriented needs to present the results of those to the users.

A key principle of the tool is the concept of source–pathway–receptor analysis. This relates both the factual cause–effect chains as well as the management options (see Fig. 1, bottom). The tool is further based on the risk assessment paradigm (Suter et al., 1993), with a solution-oriented focus (U.S. National Research Council, 2009). Risk assessments consist of a four-step approach, and aim to characterize (potential) risks of hazardous situations to support decision making under uncertainty (Fig. 1, grey part). The risk analyses were done with a single general impact assessment formula (Eq. (1)), whereby impact is some function *f* of three key conditions and (of course) receptor vulnerability:

$$\text{Impact} = f(\text{Hazard}, \text{Exposure}, \text{Quantity}). \quad (1)$$

Impacts for a receptor were considered to depend on the levels of intrinsic hazard of a facility and an associated chemical, on the presence of a pathway of exposure, and on quantity emitted. The selection and sequence in this formula were chosen in view of refined information becoming available over time after an incident (facility type and chemical class can be quickly derived from visual inspection, quantity information is often known later). This function was used to define three tiers of refinement in the tool. The tool is tiered, since time-after-event implies increased information specificity (Fig. 2). Finally, field team members are expected to be users that apply FEAT as only one of the approaches available to them, next to e.g. visual, olfactory and geographical local information, and that are trained to work under difficult conditions.

In the design phase of the tool, the impact results were initially derived for the third tier (assuming that hazard, exposure and quantity are known), and thereafter simplified or summarized for the needs of the lower tiers. In tier 3, the results are presented as impact distances for known quantities of representative chemicals, representing an easy-to-use basis for prioritization. Tiers 2 and 1 present less refined

[2] JEU: Joint UNEP/OCHA Environment Unit. UNEP: United Nations Environment Programme. OCHA: United Nations Office for the Coordination of Humanitarian Affairs.