Development of a Methodology for Prioritising Hazardous and Noxious Substances (HNS) Carried at Sea to Inform Public Health Emergency Planning and Preparedness.

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ABSTRACT

Background: *Estimates indicate some 2000 hazardous and noxious substances (HNS) are carried regularly by sea with bulk annual trade of 165 million tonnes worldwide. Incidents involving HNS have occurred regularly with over 100 reported in EU waters. Incidents in a port or coastal area could have potential public health implications. A methodology has been developed for prioritisation of HNS, based upon potential public health risks. The work, undertaken for the Atlantic Region Pollution Response programme (ARCOPOL), aims to provide information for incident planning and preparedness.*

Methods: *HNS were assessed using conventional methodology based upon acute toxicity, behaviour and reactivity. Tonnage was used as a proxy for likelihood, although other factors such as shipping frequency and local navigation may also contribute. Risk scores were used to prioritise HNS.*

Results: *Results identified the highest priority HNS as being volatile, gaseous and reactive with water. Process limitations were identified resulting in development of a software tool capable of combining chemical data from the study with user defined shipping data to produce area-specific prioritisations.*

Conclusion: *This methodology will enable a risk- based prioritisation approach to be applied to public health emergency planning and preparedness for maritime shipping.*

Key Words: *HNS Incidents, Public Health Risk, Risk Prioritisation, Emergency Planning and Preparedness.*

Background

Data indicate that approximately 90% of European Union external trade is by sea with estimates indicating up to 50,000 hazardous and noxious substances (HNS) carried by sea, and around 2000 carried on a regular basis. [1][2][3] HNS are defined as *"Any substance other than oil, which, if introduced into the marine environment is likely to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea"* [4].

Incidents involving HNS have occurred regularly with over 100 reported in EU waters from 1987 to 2007[5], whilst several hundred minor incidents / discharges of HNS have been recorded in UK waters [6]. Furthermore, new controls restricting ship to ship transfer of cargo to licensed harbour or coastal waters, whilst enabling better control of such activities, could increase the risks of spills near populated areas [7]

Incidents occurring in a port or in coastal areas can have both potential and actual public health implications as reported in several studies. Whilst there are few if any studies on the actual public health impacts of maritime HNS spills, there are many examples of spills which could have resulted in significant impact. The *Cason*, carrying 1100 tonnes of mixed HNS caught fire and ran aground off the Galician coast, Spain, 1987, resulting in 15,000 people being evacuated from the surrounding area overnight as a precaution against potential exposure[2]. Similarly impact upon public health from maritime spills has been illustrated by incidents involving oil. The *Sea Empress* spilled 70,000 tonnes of crude oil along the coast of west Wales in 1996. A retrospective cohort study of coastal populations identified exposure to be significantly associated with higher physical and psychological symptoms, such as headache, sore throat and eyes and anxiety [8].

In light of such risks a methodology has been developed to prioritise HNS based upon public health impact. The work has been undertaken for the Atlantic Region Coastal Pollution Response project (ARCOPOL) focused on the preparedness, response to and mitigation of accidental marine pollution impacting on the shoreline.

Methods

The methodology was developed based upon potential acute public health risks from HNS and aims to provide strategic risk information for public health planning and preparedness. Whilst chronic effects are important public health considerations, acute health impacts were used as the risk driver in order to reflect the type of incident scenario envisaged and because of the inherent difficulties associated with attributing chronic effects such as excess cancers to specific events / agents. Key receptors were identified as the population on shore, the shipping crew and emergency responders. No ecological receptors were included. The risk prioritisation process used conventional risk assessment methodology, as below;

Risk = Severity x Likelihood[9]

Severity

Severity was estimated as a measure of acute human health effects by determination of the toxicity of the HNS under investigation, together with the potential to reach a target receptor (chemical behaviour).

HNS were identified from the GESAMP / EHS Composite List [10] and screened for *acute* toxicity, with particular emphasis on inhalational exposure as this was considered to pose the main route for widespread public impact. Toxicity hazards were allotted scores between 2 to 4 based upon their GESAMP rating[10]. Chemical behaviour was based upon physico-chemical properties as described by the European Behaviour Classification System for accidentally spilled chemicals [11]. Scores were allotted based upon potential for exposure via inhalation / airborne pathways and to a lesser extent their potential for dermal contact (Table 1). Reactivity of chemicals with water and air was also considered. Severity was subsequently calculated as the product of the scores for toxicity and behaviour to maximise differences between chemicals[12].

Characteristics	Score	VP (kPa)	Solubility (mg/l)	Density (kg/l)
Gas	10	>101.3	<100,000	na
Gas-Dissolver	9	>101.3	>100,000	na
Evaporator	8	>3	<10,000	<1.025
Evaporator-Floater	7	>0.3	<1000	<1.025
Evap-Dissolver-Floater	6	>0.3	1000 - 50,000	<1.025
Evap-Dissolver	5	>3	10,000 - 50,000	<1.025
Floater	4	<0.3	<1000	<1.025
Floater-Dissolver	3	<0.3	<1000	<1.025
Disslover	2	<10	>50,000	na
Sinker	1	<0.3	<1,000	>1.025

Table 1: Behaviour Scores for HNS (based upon European Behaviour Classification System for accidentally spilled chemicals [11])

Likelihood

Likelihood was defined as the probability of occurrence of a spill within European Atlantic waters and was scored to reflect the amounts of HNS transported by sea as in other studies [12](Table 2). In this approach tonnage transported was used as a proxy measure of likelihood of an incident, based upon the view that larger tonnages reflect greater numbers of shipping, increasing the potential for mishaps at sea or in port. Information was obtained via a hierarchy of sources namely; UK trade data[13], EU shipping data for Atlantic and English Channel routes [14] and EU statistics[15]. Scores were allotted in line with those used by previous studies [12]. A default score of 1 was applied where no data were available.

Annual Tonnage	Score
>1,000,000	5
100,000 - 1,000,000	4
10,000 - 100,000	3
1000 - 10,000	2
<1000 or no data	1

Table 2: Likelihood Scores (based upon tonnage shipped)(HASREP [11])

Risk (Prioritisation)

The final risk assessment was calculated as the product of the severity and corresponding likelihood scores. This in turn formed the basis for subsequent risk prioritisation with the highest scoring HNS representing the highest priority (Table 3).

Results

The results of the initial prioritisation identified several of the most toxic HNS as high priority for the EU Atlantic region; with many of the highest priority chemicals being volatile or gaseous. Several HNS also fell within the top 20 priority chemicals based upon their reaction products.

CHEMICAL NAME	Toxicity	Behaviour score	Tonnage Score	Risk
CHLORINE	7	10	4	280
ETHYLENE OXIDE	7	10	4	280
METHYL AMINE SOLN	7	9	3	189
AMMONIA	5	9	4	180
2-(2-AMINOETHOXY) ETHANOL	7	8	3	168
VINYL CHLORIDE	4	10	4	160
2-AMINO-2-METHYL-1-PROPANOL	7	7	3	147
3-METHYL PYRIDINE	6	7	3	126
FORMALDEHYDE	7	9	2	126

Table 3: Priority HNS for EU Atlantic Region Based Upon Acute Public Health Impact

The prioritisation process highlighted the difficulties in obtaining accurate HNS shipping data and potential uncertainties from solely applying tonnage from national trade statistics as a proxy for likelihood. To address this, the prioritisation methodology was further developed into a usable database tool, allowing prioritisation on a port, region or wider operational basis. Using the developed assessment methodology and containing a database of 350 HNS, the tool runs on a PC using Microsoft Access and prioritises selected HNS based upon their preloaded chemical data combined with user defined shipping data. The software generates a risk based priority list of the HNS handled by that port or region, which can be saved, updated and revised as information develops over time (Figures 1 and 2). Furthermore the system enables users to add additional HNS to the database by inputting basic chemical toxicity and behaviour data as prompted by the software.

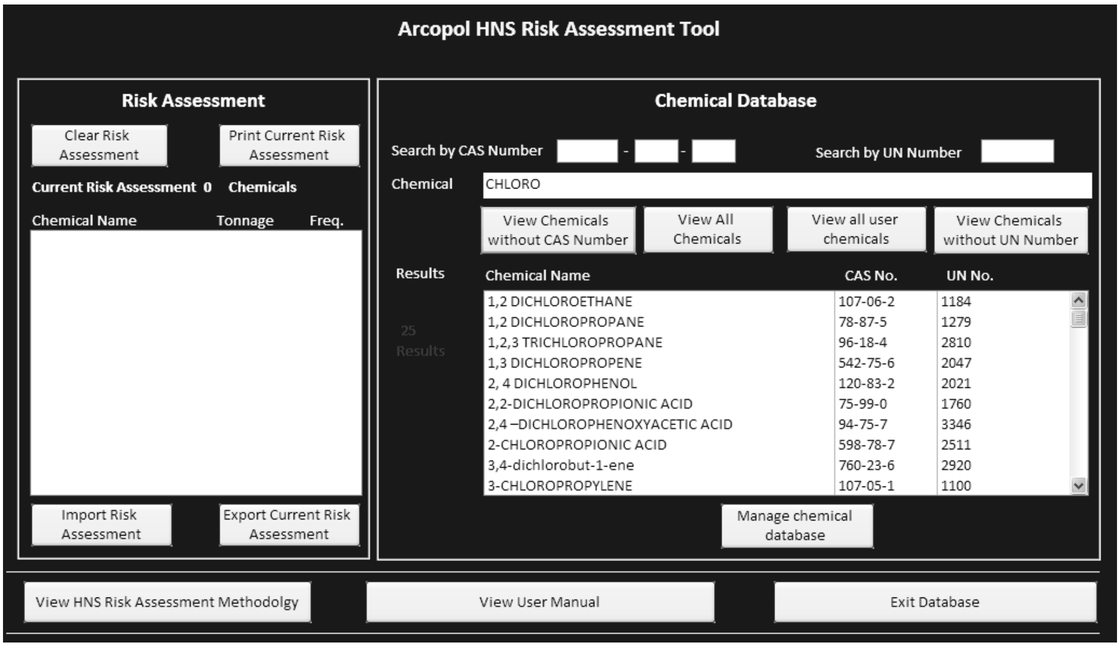

Figure 1: ARCOPOL HNS Risk Assessment Tool

HNS Prioritisation for test

Results of prioritisation for test

Printed on: 24 August 2010 by tester

Disclaimer: The authors take no responsibility for the properties applied to user defined chemicals. References to the derivation of these data should be recorded and supplied with this report on the table provided within the Documents folder. (Default chemical data - Reference Health Protection Agency 2010).

Chemical Name	Behaviour Category	Risk	Database Default	Tonnage	Frequency
CHLORINE GAS	GAS	630	☑	56984	30
1-HEXANOL	FLOATER-DISSOLVER	240	☑	758632	69
GLYOXYLIC ACID	DISSOLVER	150	☑	56894	253
1,3 DICHLOROPROPENE	EVAPORATOR	144	☑	65236	12
ALCOHOL ETHOXYLATES (as Dodecyl)	FLOATER-DISSOLVER	135	☑	65935	25
1-OCTANOL	FLOATER	128	☑	555699	99
MOLYBDENUM POLYSULFIDE LONG CHAIN AL	FLOATER	128	☑	555555	55
2,4-TOLYLENEDIAMINE	DISSOLVER	120	☑	35625	250
BETA-PROPIOLACTONE	SINKER	72	☑	26588	33
ISOPHORONE DIAMINE	FLOATER	56	☑	5696	Default Used
1,2-BUTYLENE OXIDE	DISSOLVER	48	☑	596321	52
AMMONIA	GAS-DISSOLVER	45	☑	56	Default Used

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Figure 2: Example of Prioritisation Report from ARCOPOL HNS Risk Assessment Tool

Main findings of the study

The study undertaken demonstrates a relatively simple and rapid means of prioritising HNS based upon public health risks. The process can provide useful information for relevant bodies when developing strategic plans and contingency measures, such as response resources and training programmes. It therefore forms a basis for multi-agency/multi-disciplinary planning at regional, national and international level and one that can supplement existing response materials such as the WHO Guidance [16] and the OPRC HNS Protocol[4].

Some areas for further consideration were identified, specifically in respect of the potential limitations of shipping data. The latter point was addressed by development of a usable prioritisation tool enabling operators to utilise accurate shipping data from their own ports and regions. This tool will allow planners to prioritise HNS applicable to their areas enabling resources and procedures to be focussed on those most likely to pose risks. Using this information planners and responders can then train and test procedures and maintain resilience.

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