AARHUS
UNIVERSITY
DEPARTMENT OF ENVIRONMENTAL SCIENCE

Receiver(s): Green Cross Switzerland

Report

1. Findings regarding Sea-dumped chemical warfare agents south of Vieques (PR)

Hans Sanderson

Date: 29 June 2017
Case no..: Green Cross
Ref: HS

Risk screening of sea-dumped CWA according to accounts and reference below:

Date(s) of dumping: Unknown.

Location: Unknown, but south of the island of Vieques about 16 kilometers (10 miles) in the Caribbean.

Depth: About 610 meters (2,000 feet).

Total tonnage: About 23 US tons total in six types of chemical weapons (see below) containing mustard agents, cyanogen chloride, and tabun.

Weapons & agents:
(1) 34 4.2-inch (11-centimeters) mortars filled with mustard agents (less than 1 ton total of mustard agents).
(2) 124 115-pound (52-kilogram) bombs filled with 51.8-pounds (23.5 kilograms) of cyanogen chloride each (3 tons total of cyanogen chloride).
(3) 29 500-pound (227-kilogram) bombs filled with 176 pounds (80 kilograms) of cyanogen chloride each (3 tons total of cyanogen chloride).
(4) 8 1,000-pound (454-kilogram) bombs filled with 351 pounds (159 kilograms) of cyanogen chloride each (1 ton total of cyanogen chloride).
(5) 1,842 4.2-inch (11-centimeters) mortars filled with 4.2 pounds (1.9 kilograms) of tabun (GA) each (4 tons total of tabun).
(6) 110 250-kilogram (550-pound) German bombs filled with 206 pounds (93.4 kilograms) of tabun (GA) each (11 tons total of tabun).

Sources: US Department of Defense, Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, "Chapter 10, Sea Disposal of Military Munitions," *Defense Environmental Programs Annual Report to Congress -- Fiscal Year 2009*. April 2010, p. 106.

Environmental chemistry & toxicology
Aarhus University
Frederiksborgvej 399
PO box 358
DK-4000 Roskilde
Denmark

Tel.: +45 8715 0000
Fax: +45 8715 5010
E-mail: envs@au.dk
Web: envs.au.dk/en

http://www.smithsonianmag.com/science-nature/decaying-weapons-world-war-II-threaten-waters-worldwide-180961046/
https://www.google.com/maps/d/viewer?mid=1IU5kWbDrPOrUccOrQ0In4Ca-zWQ&hl=en_US&ll=39.14633290123096%2C-3.427734375&z=2

Table 1: Tonnage and physical/chemical properties (Sanderson et al. 2007) and EPI Web:

Compound	CAS#	Total tonnage (t)	Log Kow	KoC	BCF	Water Solubility (mg/L)	Persistent	Half-life in water (hrs)
Mustard gas (HD)	505-60-2	1	2.41	275	14.3	684	Persistent	900
Cyanogen chlorid (CK)	506-77-4	7	-0.38	4.5	3.1	160,000	Not persistent	360
Tabun (GA)	77-81-6	15	0.29	22.5	3.16	98,000	Not persistent	360

It is clear from the Tab 1 that CK and GA are very hydrophilic with rapid dissipation when in contact with water. They will have a low tendency to sorb to sediments (low KoC) and the low bioconcentration factor further suggests that they will not bioaccumulate or biomagnify (low BCF and low Log KoW). In an occupational/on land context (CK) reacts slowly with water or water vapor to form toxic hydrogen cyanide and hydrogen chloride, and GA also decomposes slowly in water after exposure. Raising the pH increases the rate of decomposition significantly. HD is more stable in water than CK and GA. The hydrolysis of sulphur mustard yields hydrochloric acid and thiodiglycol as the primary dissipation products.

Since we don't have measured environmental concentrations of these compounds and their dissipation products we have to initially rely on comparative studies to assess the potential exposure and risk. In the Baltic Sea we have estimations of 74 tonnes of other blood agents like GA was dumped – hence we have sampled more than 400 sediment and dozens of porewater and near-bottom bulk water and never found traces of GA at and near the known dump-site (Sanderson et al. 2014). We have not looked for CK in any of the samples as this has not been reported dumped in the Baltic Sea – however, the assumption is that it would mirror the result of GA due to similar physical/chemical properties.

When modelling these exposures we found for zyklon B, an alkanenitrile compound similar to CK, with similar hydrophilic properties and miscible mixing with water as CK, we found maximum near bottom-water contractions (20 cm above the sea-floor) of 0.04 µg/L in the Baltic Sea (Sanderson et al 2008). This would equate to ~ 0.004 µg/L assuming a similar size dumpsite (100 km^2) in the waters outside Vieques as the

amounts are roughly one tenth - or just with 7 tonnes as opposed to 74 tonnes tonnage in the Baltic. We assume that the results for GA will be in the same order of magnitude approximately 0.008 µg/L. However, these modelled results are very conservative and would need experimental verification – and as mentioned, we have not found them in water nor sediments before.

In the Baltic Sea dump site there was dumped 7027 tonnes of HD – so more than 7000 times more that in the Vieques location. Conducting a similar analysis as above for HD results in a modelled exposure of 0.0006 µg/L in near bottom water.

Only one out of more than 400 sediment samples from the Baltic Sea has contained intact HD – otherwise we have only found dissipation products of HD. We have never detected intact HD in the near bottom water in the Baltic Sea. It is hence highly unlikely that the HD dumped outside Vieques will amount to an exposure that would result in risks to people – however, these are but modelled and extrapolated values, which could be tested with actual sampling at the location, but it is our assumption that these would be negative.

There are restrictions on fishing in the dumpsite in the Baltic Sea due to occupational, environmental and consumers risks, similarly we recommend that fishing in all dumpsites, including near Vieques, be restricted.

References:

Sanderson H., Thomsen M., Fauser P., Sørensen PB. (2007): PBT screening profile of chemical warfare agents (CWAs). *J Haz Mat*. **148**, 207-215.

Sanderson H., Thomsen M., Fauser P., Sørensen PB. (2008): Screening level fish community risk assessment of chemical warfare agents in the Baltic Sea. *J Haz Mat*. **154**, 846-857.

Sanderson H., Fauser P., Rahbek M., Larsen JB. (2014): Review of environmental exposure concentrations of chemical warfare agent residues and associated the fish community risk following the construction and completion of the Nord Stream gas pipeline between Russia and Germany. *J Haz Mat*. **279**, 518-526.