NORD STREAM 2 CWA MARINE RISK SCREENING

Scientific Report from DCE – Danish Centre for Environment and Energy No. 301 2019

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Data sheet

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Abstract: The aim of this report is to assess the risk to the marine environment of detected chemical warfare agent (CWA) residues and the added risk associated to the resuspension of sediment particles from construction intervention works of the Nord Stream 2 gas pipeline in the Baltic Sea. Based on chemical analysis of sediment samples and subsequent risk modelling it is found that the added risk represents less than 1 % of the background risk. As the overall background risk is low, it is concluded that the added marine environmental risk of the detected CWA residues, from intervention works, is negligible.

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Contents

Introduction

Following the end of the Second World War, Germanys approximately 65,000 tonnes stockpiled Chemical Warfare Agent (CWA) munitions were ordered by the allied forces to be destroyed during the second half of 1947. The Bornholm basin in the Baltic Sea received more than half of Germanys CWA arsenal with dumping of approximately 11,000 tonnes active CWA chemical substances (HELCOM, 1994). The exact locations of the dumpsites are ambiguous. The primary, and designated, dumping was conducted in a circular area with a radius of three nautical miles, with the centre coordinates at 55ºE21"N and 15ºE37'02"E covering an area of 99 km². However, not all CWA was dumped at the designated site, hence a secondary, and more realistic dumpsite is located roughly at 55°10"N to 55°23"N and 15°24"E to 15°55"E, covering 892 km². Lastly, the tertiary risk zone area where CWA may be encountered covers 9104 km² around Bornholm. The pipeline north of Bornholm is thus within the tertiary dumping area in the Northwestern end (station 15-23) (Fig 1). The aim of this report is assess the risk the dumped CWA and residues constitute towards the marine environment.

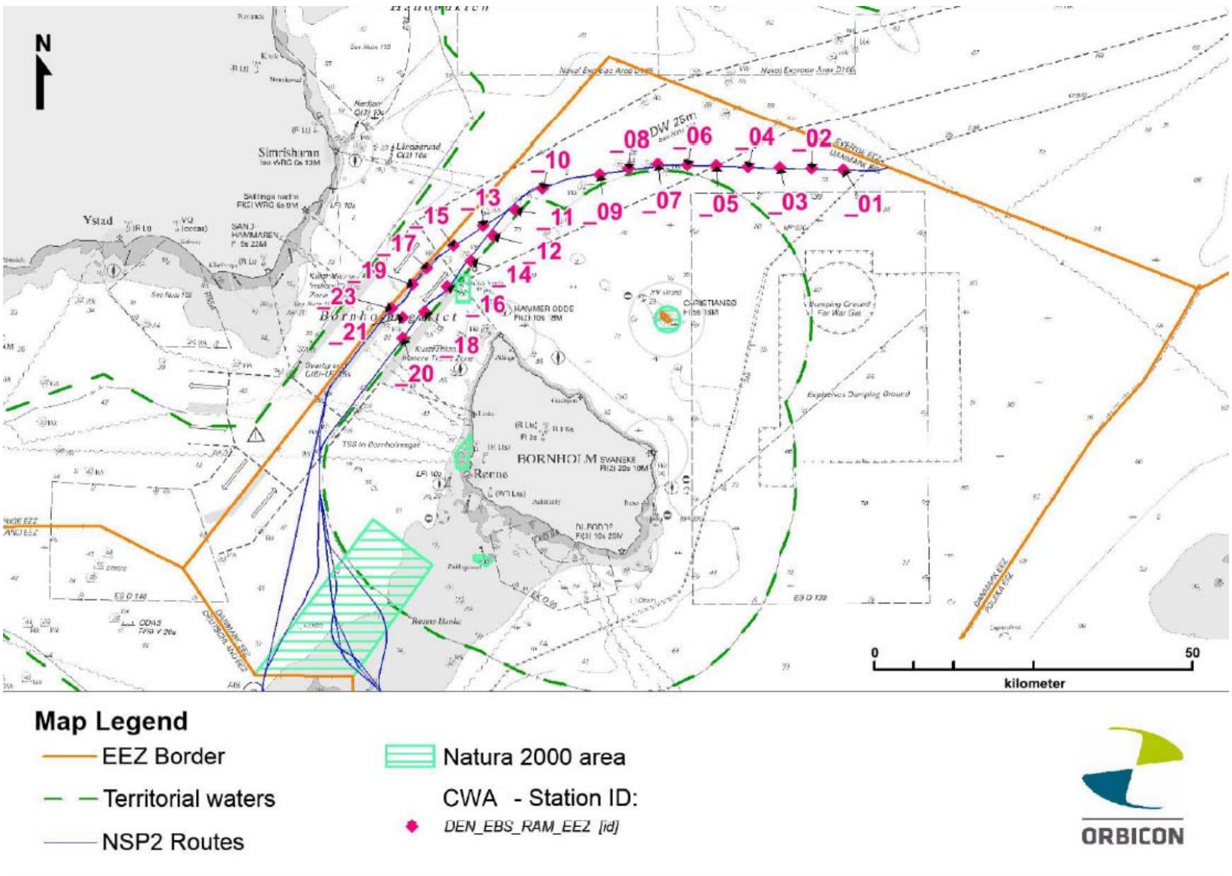


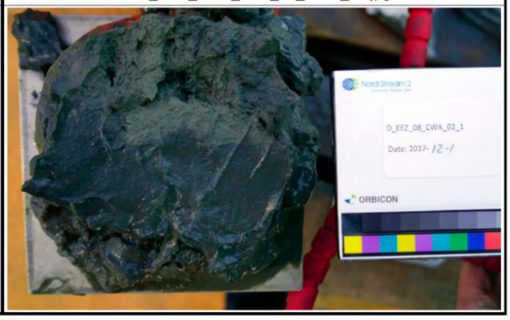
Figure 4-1. Survey stations for CWAs in the surface sediments in the Danish EEZ in November/December 2017.

Figure 1 Nord Stream 2 route.

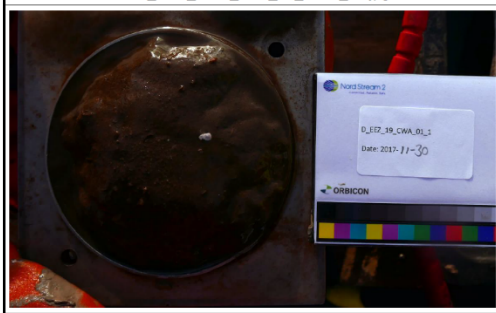
1. Environmental CWA exposures

Forty samples were collected and 26 CWA targets and metabolites were analysed. Two samples were positive with one CWA compound in each. Two CWA metabolites were detected in the samples from the upper sediment at water depths at 87 and 66 m. Figure 2 depicts the collected samples and their characteristics.

Station	Position (WGS 84)				Depth	Date
DEN_EBS_RAM_EEZ_08	UTM (ZONE 33 N)		Geographical		87 m	2017-12-01
	Easting	Northing	Latitude [°]	Longitude [°]		
	505972.94	6154165.45	55.53350	15.09463		
Composition	**Colour**	**Sample depth**	**Composition**		**Colour**	**Sample depth**
Silt, mud and soft clay	Grey	0-5 cm	Silt, mud and soft clay		Grey	10-30 cm
Smell	**Oxi layer**	**Various**	**Smell**		**Oxi layer**	**Various**
A little	0 mm	-	A little		-	-
Photo ID of 0-5 cm depth			**Photo ID of 10-30 cm depth**			
DEN_EBS_RAM_EEZ_08_CWA_01.jpg			DEN_EBS_RAM_EEZ_08_CWA_02.jpg			



Station	Position (WGS 84)				Depth	Date
DEN_EBS_RAM_EEZ_19	UTM (ZONE 33 N)		Geographical		66 m	2017-11-30
	Easting	Northing	Latitude [°]	Longitude [°]		
	471828.21	6135866.64	**55.36830**	**14.55552**		
Composition	**Colour**	**Sample depth**	**Composition**		**Colour**	**Sample depth**
Silt mud on top of clay	Brown and dark grey	0-5 cm	Clay		Dark grey	10-30 cm
Smell	**Oxi layer**	**Various**	**Smell**		**Oxi layer**	**Various**
No smell	2 mm	-	No smell		-	-
Photo ID of 0-5 cm depth			**Photo ID of 10-30 cm depth**			
DEN_EBS_RAM_EEZ_19_CWA_01.jpg			DEN_EBS_RAM_EEZ_19_CWA_02.jpg			



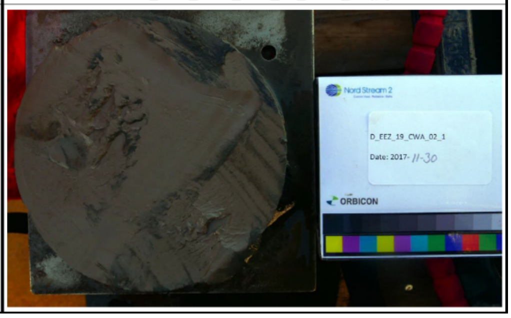


Figure 2 CWA positive samples collected (W-PE-EIA-PDK-REP-RNORB5EN-01).

The measured concentrations of CWA in the samples are summarized in Table 1 below (Orbicon 2018).

Table 1 Measured environmental concentration in the sediment of CWA metabolites.

Compound	CAS#	Location/ station[1]	Concentration (µg/kg dw ±SD)
1,2,5 trithiepane	6579-93-8	08	0.8 ±0.04
Bis(2-chlorovinyl)arsinic acid	677354-21-9	19	8.3±0.9

We applied the same methods based on adapted equilibrium partitioning as has been documented in the previous studies (Sanderson and Fauser 2015; Sanderson et al. 2014). We used the measured inherent CWA concentrations to calculate the worst-case sediment porewater exposure concentrations, which represent the maximum bioavailable concentration to pelagic organisms. Table 2 summarizes these findings.

Intervention works consist of trenching and rock placement as outlined in Ramboll (2018). We assumed sediment resuspension amounts from the trenching and rock placement based on Ramboll calculations (JB. Larsen, Pers. Comm., 2018) to be 30.7 and 5.6 mg/L, respectively, in the bottom bulk water at a distance of 200 m from the intervention works for location 08 and 0 and 1.0 mg/L, for trenching and rock placement respectively, for location 19. As in Sanderson and Fauser (2016) a worst-case scenario for additional concentrations in bottom-layer bulk water from intervention works is that once sediment particles are suspended to the bulk water all the sorbed CWAs are instantaneously released and mixed within a release area. The total CWA concentration in the bottom-layer bulk water from inherent and added sediment contributions is thus calculated as a sum of the sediment pore water CWA concentrations derived from measurements and calculated added CWA concentrations from intervention works.

The resulting predicted CWA environmental concentrations in the steady state porewater (without disturbance of the pipeline installation), the added/re-suspended water concentration (due to the pipeline installation disturbance), and the combined total water concentrations rare summarized in Table 2 below.

Table 2 Calculated CWA Predicted Environmental porewater exposure concentrations (PEC) based on the measured environmental sediment concentrations.

Compound	Porewater (µg/L ±SD)	Added bulk water (µg/L ±SD)	Total water (µg/L ±SD)
1,2,5 trithiepane	0.038 ±0.002	0.00003 ±0.000002	0.038 ±0.002
Bis(2-chlorovinyl)arsinic acid	0.189 ±0.02	0.000008 ±0.000001	0.189 ±0.021

[1] See Figure 1.

2. Environmental CWA toxicity

1,2,5 trithiepane belongs to a group of cyclic mustard gas degradation products. We have found that the toxicity of these for the structurally and chemically similar compound are quite comparable and in the same toxicity range from 1-10 mg/L (Christensen et al 2016). We have since tested in depth the toxicity of one of these compounds 1-Oxa-4,5-dithiepane and found the following toxicity values from Sanderson and Fauser (2016) and Storgaard et al. (2017) as representative of the category, see Table 3 below.

Table 3 Toxicity ranges of 1-Oxa-4,5-dithiepane.

Organism	NOEC mg/L
Allivio fischeri (bacteria)	2.2
Algae (chronic 96 hrs)	8.41
Daphnia magna (chronic 21 days)	0.825
Zebra fish (chronic 14 day)	1.5

We hence use these values to describe the toxicity of the detected 1,2,5 trithiepane. The resulting lowest predicted no-observed effect concentration (PNEC) is thus *Daphnia magna;* 0.825/500 by an assessment factor of 500 = 0.00165 mg/L, for 1,2,5 trithiepane (Sanderson and Fauser 2016).

Bis(2-chlorovinyl)arsinic acid is an organic arsenic CWA metabolite of Lewisite II and in accordance with previous studies we used the acute fish community Species Sensitivity Distribution (SSD) proxy of PNEC of 290 µg/L (Sanderson et al. 2014).

The resulting PNEC values are summarized in Table 4 below.

Table 4 CWA metabolite PNEC values.

Compound	PNEC (µg/L)
1,2,5 trithiepane	1.65
Bis(2-chlorovinyl)arsinic acid	290

3. Environmental CWA risk

We calculated both the background environmental risk quotient (RQ = PEC / PNEC) as well as the added RQ due to the installation of the pipeline. If the RQ is greater than 1 this indicates that the risk is unacceptable and further investigations and / or management actions are needed.

Table 5 summarizes the RQs for the steady state total background CWA risk, and the added risk due to the pipeline installation and sediment resuspension (Table 5).

Table 5 Risk Quotients (RQ).

Compound	Location/ Station[1]	Total RQ (background + added RQ)	Added RQ
1,2,5 trithiepane	08	0.023	0.00002
Bis(2-chlorovinyl)arsinic acid	19	0.0007	0.000000003

It is clear that the predicted environmental risk due to the installation of the Nord Stream pipeline 2 is low.

Conclusions

The overall background CWA risk is low. Moreover, it is clear from this analysis, that the added marine environmental risk relative to the background risk of the detected CWA metabolites is negligible. Chemicals with high sorption coefficients (Koc) have a relatively higher impact on the added RQ due to the larger amount of chemical that is sorbed to the re-suspended particles. However, the two detected compounds have relatively low Koc values and furthermore their measured concentrations are relatively low. The added RQs to the marine environment due to the installation of the NSP2 pipeline represent less than 1% of the background RQs of the inherent detected dumped CWA metabolites. As the overall background CWA RQ is low, it is clear from this analysis, that the added marine environmental RQ of the detected CWA metabolites, from intervention works, is negligible. The added risk to the marine environment in this analysis due to the installation of the NSP2 pipeline represent less than 1% of the background risk of the inherent detected dumped CWA metabolites.

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