Impact of dumped munitions on the Baltic Sea environment

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National project 2002-2004
IAEA Technical Cooperation project (2004-2005)

- Studied parameters did not show any changes of the environment at the chemical munitions dumpsite.
- Higher As concentrations were found at the chemical munitions dumpsite, compared to other sites. However, As concentrations were low relative to other investigations.
CHEMSEA project 2011-2014

- Chemical warfare agents (Clark I/II-related; Triphenylarsine and PDCA-related) were found in sediments of station CHEMSEA5.
The main aim of the project – establishment of the monitoring network observing CW dumpsites in the Baltic Sea, using Autonomous Underwater Vehicles (AUV’s) and Remotely Operated Underwater Vehicles (ROV’s).
Are dumped war materials causing harm to the Baltic Sea ecosystem?

- munitions containing chemical warfare agents (CWA)
- conventional munitions containing toxic explosives (e.g., TNT)
- toxicity (effect thresholds)
- exposure ➔ biological effects on local biota
- evidence of exposure
  - **bioaccumulation** (parent compounds, metabolites/degradation products)
  - **effects at different biological levels**
    - ✔ molecular/biochemical
    - ✔ cellular
    - ✔ tissue (pathology)
    - ✔ physiology
    - ✔ reproduction
    - ✔ behaviour
Toxicity threshold studies
Toxicity of CWAs

- *in vitro* studies with fish hepatocytes showed that DPA[ox] forms a glutathione conjugate (DPA-SG)
- the main metabolite two orders of magnitude toxic than the DPA[ox] itself
- other novel metabolites of DPA[ox] were also identified using high resolution mass spectrometry

21-day reproduction test with the water flea (*Daphnia*):
- **Clark I** toxic at environmentally realistic concentrations (NOEC 625 ng l⁻¹)
- **TDG (mustard gas hydrolysation product)** toxic threshold very high (250-500 mg l⁻¹)
Bioaccumulation

CWAs in biota

• sampling in Bornholm, Måseskär and Skagerrak dumpsites (175 individuals in total)
• trace amounts of phenylarsenic CWAs were detected from marine biota samples for the first time
  • 25% of analysed muscle tissue samples contained CWAs

• chemicals were analysed as their oxidation forms
  → total CWAs concentrations in marine biota remain still unknown
Bioeffects
Laboratory exposure of mussels to TNT: acute (96 h) and chronic (21 d) toxicity tests

21-day experiment:

**Shell closure**
*(behavioural response)*

**Lipofuscin accumulation**
*(metabolic end product of peroxidation processes)*

**Neutral lipid accumulation**
*(connected to exposure to organic pollutants)*
Bioeffects
Field studies: field-collected and transplanted mussels in target areas

- WWII wreck “M451” in the Gulf of Finland
- Finnish Navy divers collected mussels growing on the wreck and on top of the depth charges before the deactivation operation
- reference samples from a nearby coastal area
**Bioeffects**

Field studies: field-collected and transplanted mussels in target areas

Mussel caging experiment
- a large (ca. 350 kg) sea mine in the Gulf of Finland
- one cage close to the mine (20 m) and two reference cages 1 and 2 nm from the “hot spot”
Bioeffects
Field studies: hagfish in Skagerrak near a CWA dumpsite

Foci of cellular alteration in liver tissue (pre-cancer state)
Bioeffects
Field studies: flatfish in Kolberger Heide sea mine dumpsite
The Toolbox
From suspicion to decision

The case
- For a given geographical maritime area there is suspicion that dumping of munitions took place in the past.

The concern
- Do these munitions and their toxic chemical components pose a threat to marine organisms in their habitat?
The Toolbox
From suspicion to decision

The solution
• apply the DAIMON Toolbox because it provides
  ▪ concept & strategy
  ▪ selection of appropriate methods
  ▪ method description (fact sheets)
The Toolbox
From suspicion to decision

TOOLBOX PATHWAYS

Pathway 1:
- Suspicion
- Screening Study
- Risk assessment
- Decision Support System
- Decision

Pathway 2:
- Suspicion
- Screening Study
- Detailed Study
- Risk assessment
- Decision Support System
- Decision

Tier 1 Tier 2
The Toolbox
From suspicion to decision

SUSPICION: Ecological risk due to dumped munitions?

TIER 1: SCREENING STUDY

- Check availability of data facilitating a risk assessment
- sufficient data for risk assessment available
- no or insufficient data for risk assessment
- Run risk assessment
- Feed data into Decision Support System
- Decide on actions to be taken

3 Options
- If there is no indication of a problem: STOP
- If results are unclear, do a Detailed Study
- If a problem is indicated, run risk assessment

optical/sonar/magnetometric screening
chemical screening sediment
biological effects screening
The Toolbox
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**SUSPICION: Ecological risk due to dumped munitions?**

**TIER 1: SCREENING STUDY**

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**3 Options**

- optical/sonar/magnetometric screening
- chemical screening sediment
- biological effects screening

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If results are unclear, do a Detailed Study
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The Toolbox
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**SUSPICION:** Ecological risk due to dumped munitions?

If the results from the Screening Study were unclear:

- **TIER 2: DETAILED STUDY**
  - Do more chemical measurements
  - Do more bioeffect measurements
  - Apply other approaches

2 Options

- If there is no indication of a problem: STOP
- If a problem is indicated, run risk assessment

Decide on actions to be taken

Feed data into Decision Support System

Run risk assessment
The Toolbox

From suspicion to decision

[Image of a toolbox with various tools labeled with different methods and techniques such as Munitions Identification, Munitions Detection, Chemical Water, Chemistry Sediment, Biomarkers in situ, Exposure Studies, Lab Toxicity Studies, Data Analysis & Assessment, Decision Support, DAIMON, EcoTox Toolbox, and daimon Decision Aid for Marine Munitions]
The Toolbox

From suspicion to decision

**Munitions detection & identification**
- Side scan sonar
- Sub-bottom profiler
- Magnetometry
- Neutron Activation Analysis
- Camera systems
- AUV, ROV
- Modelling

**Hazardous substances**
- Chemical analysis of CWA and degradation products (e.g. GC-MS, LC-HESI /MS/MS)
- Chemical analysis of explosives and degradation products (e.g. LC-QQQ-MS)

**Biological effects**
- Biomarker battery
- General, specific biomarkers
- Fish, Mussel

**Other approaches**
- *in situ* exposure (Fish, Mussels)
- Lab toxicity tests
- Sediment/water bioassays

**Data analysis & assessment**
- Statistics
- Assessment criteria
- Integrated risk assessment

**Decision support**
- Decision Support System

**Other approaches**
- *in situ* exposure (Fish, Mussels)
- Lab toxicity tests
- Sediment/water bioassays
In 2010, under Lithuania’s initiative, the United Nations General Assembly at its sixty-fifth session adopted by consensus the resolution “Cooperative measures to assess and increase awareness of environmental effects related to waste originating from chemical munitions dumped at sea”.

Resolution adopted by the General Assembly

[on the report of the Second Committee ([4/57/418 and Corr. 1])]

65/149. Cooperative measures to assess and increase awareness of environmental effects related to waste originating from chemical munitions dumped at sea

The General Assembly,

Recalling the recommendations of the United Nations Conference on the Human Environment, held in Stockholm in June 1972;¹


Recalling relevant international and regional instruments such as the United Nations Convention on the Law of the Sea,⁴ the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter,⁵ the Convention for the Protection of the Marine Environment of the North-East Atlantic,⁶ the Convention on the Protection of the Marine Environment of the Baltic Sea Area,⁷ the Convention for the Protection and Development of the Marine Environment of the

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DAIMON Open Day Event on the 7th of February 2019 in Bremerhaven, Germany

„This was achieved with a very good cooperation among all United Nations member States and remarkable input by scientific community and civil society. The core objective of the resolution, adopted also in 2013 and 2016, is to encourage States, and international and regional organizations to keep under observation this global issue, voluntarily share information on this matter, and strengthen international efforts in raising awareness in order to create a safer, cleaner, and sustainable environment for all of us“ (Ambassador Vidmantas Purlys, Permanent Representative of Lithuania to OPCW)
Side event in the framework of the CWC IV Review Conference

The permanent representations of the Republic of Lithuania and the Republic of Poland to the Organization for Prohibition of Chemical Weapons (OPCW) have organized a side event in the framework of the CWC IV Review Conference: International efforts on sea dumped chemical weapons (23 of November, 2018)
The workshop with national stakeholders and DAIMON project partners was held in the Ministry of Environment of Republic of Lithuania. Decision Support System (DSS) has been presented and discussed. This discussion is being developed further in order to achieve the best possible result for decision-making authorities.
DAIMON team,
project meeting in Klaipeda,
Lithuania, September 2018