Microbial responses to chemical weapons dumped in the Baltic Sea

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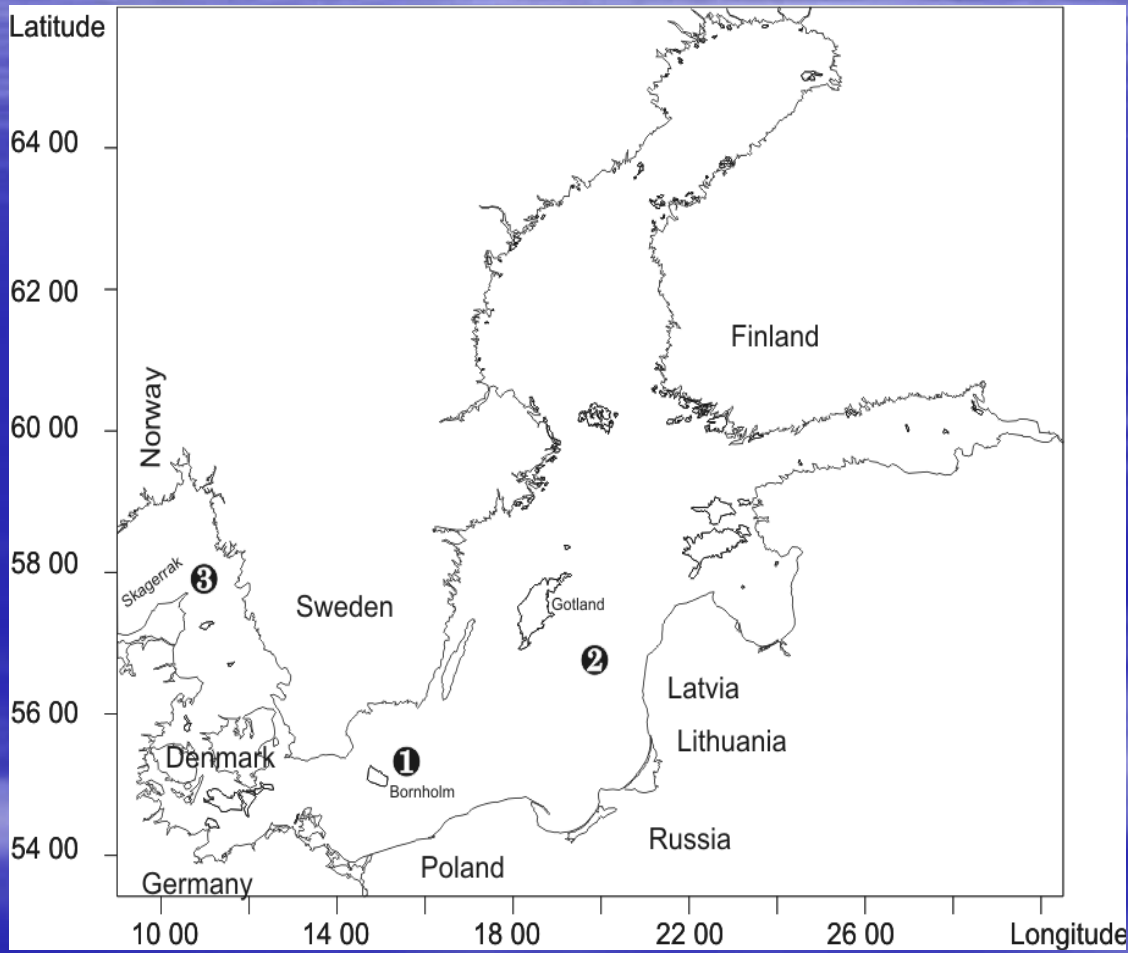
In 1994-2007, the ecological situation around sunken CW was monitored under the Marine Ecological Patrol Programme and European integrated project MERCW.

This allowed the three existing CW dumping sites to be generally mapped and classified according to the environmental hazard they pose.



Baltic Sea dump sites

- The Liepaja scattered non-localized dumping site (250-330 km2) is largely dispersed over the central Baltic Sea bed (the Gotland basin). This plot is the least hazardous;

- The Bornholm scattered localized dumping site (100-150 km2) in the Bornholm trench presents an actual environmental hazard;

- The Lusikil (Måseskär) concentrated dumping site (CW in sunken ships) in the Strait of Skagerrack covers an area of ca. 25 km2.

- Among chemical warfare agents that have been dumped in the Baltic after World War II, mustard gas and arsenic-containing substances can present the greatest hazard to the Baltic Sea ecosystem;

- The focus of the investigation was on mustard gas and its possible effect to Baltic Sea microbiota.

Microbiological characteristics of Baltic Sea near-bottom water

Dumping site	Number of monitoring stations		Total bacterial number, 10^6/ml	Bacterial biomass, mg/ml	Number of heterotrophs	
	Total	Stations where mustard tolerant microorganisms have been revealed			Total, 10^4/ml	Mustard gas tolerant microorganisms, % of total number of heterotrophs
Gotland Basin (SW of Liepaja)	29	1	1,3 – 4,2	1,1 – 3,0	0,6 – 2,0	up to 20
Bornholm Basin (E of Bornholm)	36	14	0,7 – 5,3	0,6 – 4,9	0,5 – 3,2	up to 85
Måseskär (W. of Sweden)	27	7	0,5 – 7,1	0,4 – 6,5	0,2 – 4,9	up to 98

- We found that mustard gas hydrolysis products (MGHP) - tolerant microorganisms were predominant in near-bottom water in many stations in the Baltic Sea dumping areas;
- Microbiological investigations revealed the concentration of MGHPs-tolerant microorganisms up to 20 - 98% of total number of heterotrophs in Gotland Deep, Strait of Skagerrack and Bornholm Basin.

- Formation of virtually accumulating cultures of microorganisms can be due to the appearance in the environment of a new for it compound, mustard gas, acting as a selection agent;

- The microbiological data correlated with the results of the direct measurement of CW agents. CW agents and their derivatives were detected by chemical analysis of the sediment samples at the monitoring stations characterized with high level of MGHPs-tolerant microorganisms.

Taxonomic structure of the Baltic Sea bacterioplankton at CW dumping areas

Taxonomic structure of the bacterioplankton	Taxonomic structure of the bacterioplankton in sites of possible leaking of mustard gas into the environment
Bacillus	*Pseudomonas*
Pseudomonas	*Bacillus*
Alcaligenes	*Flavobacterium*
Sphingomonas	*Alcaligenes*
Achromobacter	Others: <15%
Flavobacterium	
Arthrobacter	
Acinetobacter	
Micrococcus	
Flectobacillus	
Planococcus	
Others: < 25%	

- The "abnormal" sites demonstrated reduced diversity of microbiota. At many stations the dominance of minimal number of species in near-bottom water was observed;
- The species diversity of the microbial population at the dump site was reduced compare to other sites, most probably, because of an increase in the number of MGHPs-tolerant microorganisms;
- The reduction in the species diversity of bacterioplankton suggests a decrease in the stability of the biosystem as a whole.

- From among bacterial cultures tolerant to mustard gas hydrolysis products the MGHPs-degrading microorganisms were isolated. The collection of microorganisms degraders of mustard gas hydrolysis products was created;

- The main properties of these microorganisms were the tolerance to MGHPs, and the ability to utilize the major product of hydrolysis, thiodiglycol, as the sole source of carbon and energy;

- The isolated bacteria were able to degrade thiodiglycol under low temperature. These ability is important for the marine environment, particularly for the dump sites, where water temperatures rarely exceed 7 °C.

Conclusions

- Microbiological analysis of near-bottom water samples in the Baltic Sea chemical weapon dumping areas has revealed high level of microorganisms tolerant to mustard gas hydrolysis products in the Bornholm dump site as well as near Liepaja, and in the Skagerrak dump site;
- The "abnormal" sites demonstrated reduced diversity of microbiota. The reduction in the species diversity of bacterioplankton suggests a decrease in the stability of the biosystem as a whole;
- High number of microorganisms tolerant to MGHPs in near-bottom waters indicates possible leaking of CW agents into the environment and contamination of water and sediments with mustard gas and products of its hydrolysis in dumping areas;
- The method for microbial indication of chemical weapon dump sites has been developed;
- From among bacterial cultures tolerant to mustard gas hydrolysis products the MGHPs-degrading microorganisms were isolated;
- The results suggest a potential for MGHPs biodegradation by natural occurring populations of near-bottom water and sediment microorganisms.

We are open for cooperation!

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