Ecological impact of sea dumped chemical warfare on Baltic Sea ecosystem

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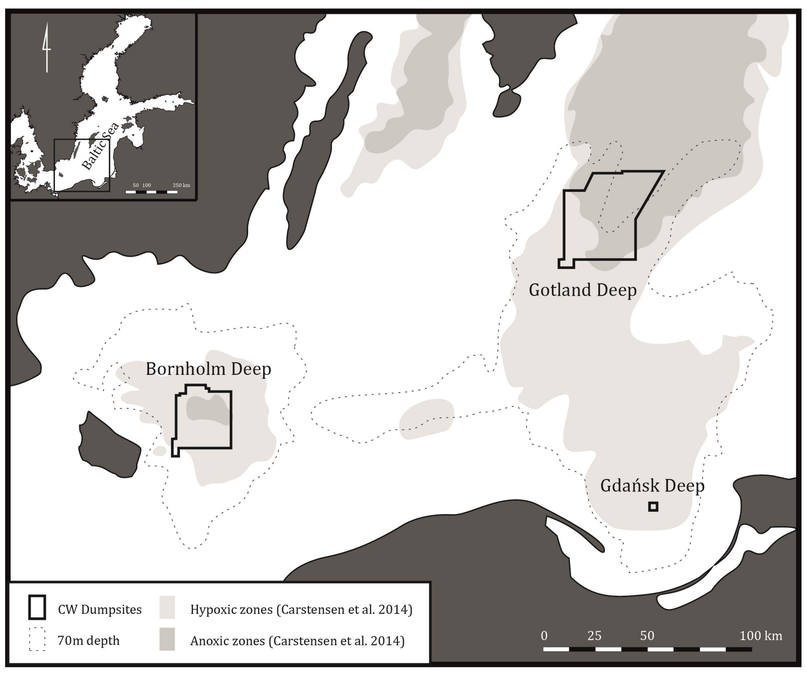
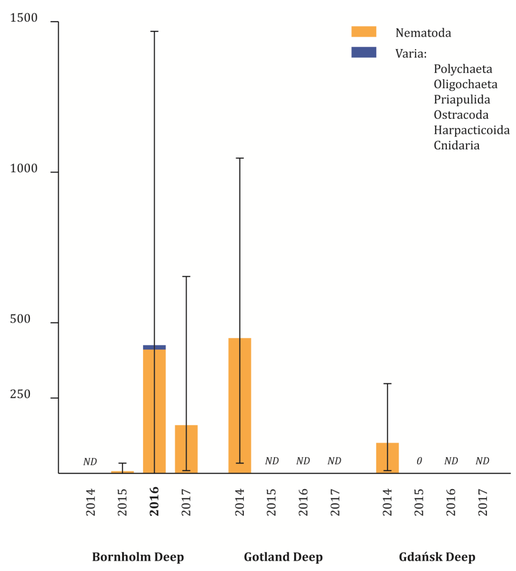


INTRODUCTION

Covering a surface area of 415 000 km2, the Baltic Sea is relatively shallow, with an average depth of 52 meters. It was formed during the last glaciation and the present level of salinity stabilized 2000 years ago, becoming one of the largest brackish ecosystems in the world. Salinity values in the Baltic Sea range between 1–20 PSU, with an average of 7 PSU. Although being characterized by low biodiversity, this young ecosystem provides multiple natural services for a large human population living in the catchment area. This makes it highly sensitive to many forms of human impact, which includes contamination by xenobiotics. Baltic Sea served as a dumping site for 50 000 of CW, that contained at least 15 000 tons of CW Agents – CWA. Since the beginning of sea dumped chemical warfare research in the Baltic Sea area, multiple CWA and their degradation products have been detected in Baltic Sea sediments and in pore waters.

HABITAT DESCRIPTION

To understand the potential ecological impact of sea dumped chemical warfare on the Baltic Sea ecosystem we have performed series of studies to describe the habitat types in the dumpsite areas. It turned out that those areas are already heavily affected by anthropogenic disturbances, especially by the hypoxia and anoxia that are caused by Baltic Sea eutrophication (Fig. 1). This results in low biodiversity (even within *meiofauna*) of Baltic Sea deeps, where chemical warfare was sea dumped (Fig. 2). For more information please check: Deep Sea Habitats in the Chemical Warfare Dumping areas of the Baltic Sea at *Science of the Total Environment* (**Czub et al. 2018**), where multiple parameters and approaches are described in details. This includes multiple effects observations of Major Baltic Inflow (MBI) that occurred in 2014.

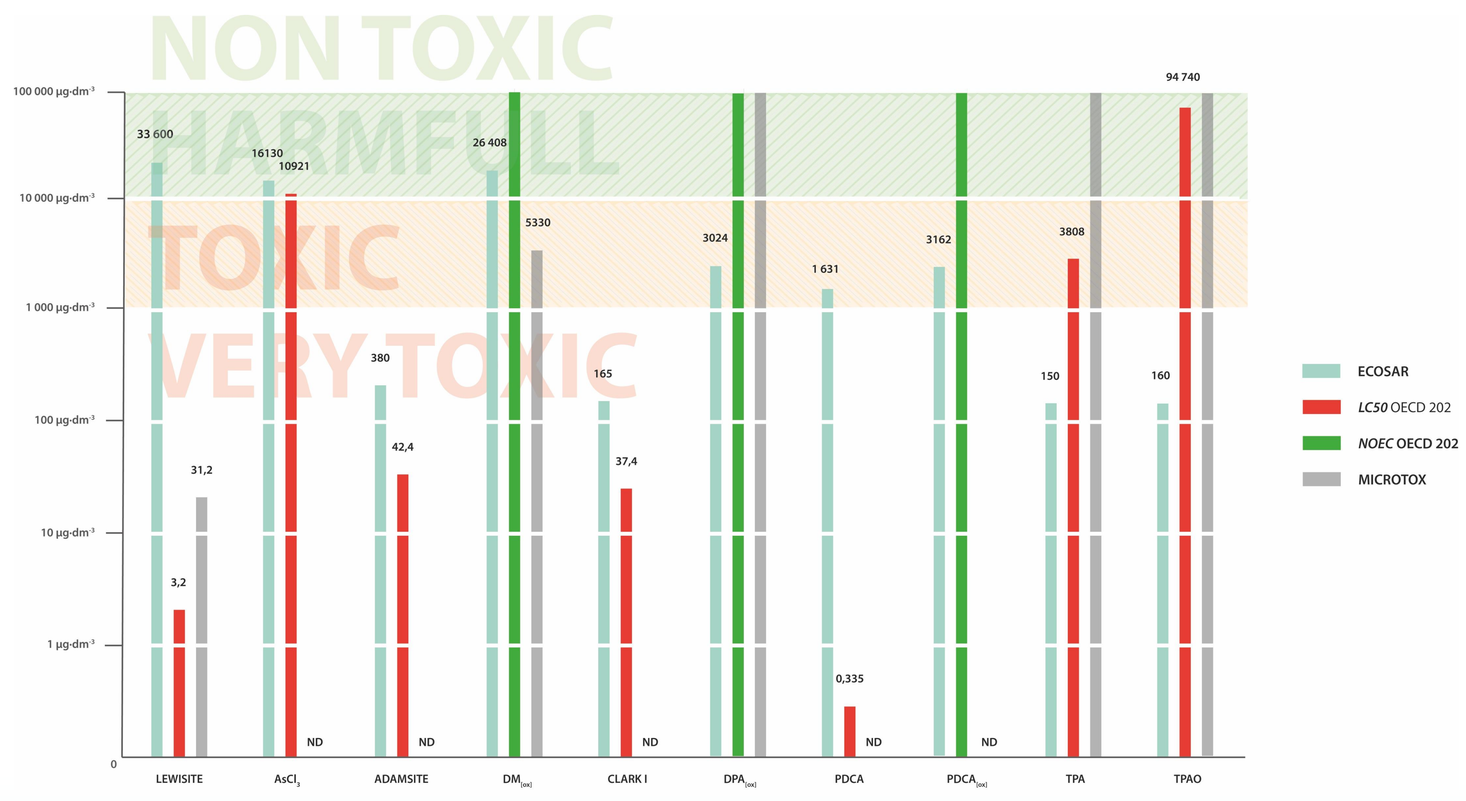


ORGANOARSENIC CWA TOXICITY TESTS

To understand the actual ecological threat for aquatic organisms caused by a presence of CWA in local environment additional studies have been conducted in laboratories of Military University of Technology in Warsaw. OECD *Test No. 202: Daphnia sp. Acute Immobilisation Test* (**OECD, 2012**) was applied to test toxicity effects of 6 organoarsenic parent CWA compounds: **Lewisite**, **Adamsite** (DM), **Clark I** (DPA), **Phenyl-dichloroarsine** (PDCA), **Triphenylarsine** (TPA) and **arsine trichloride** ($AsCl_3$). Additionally 4 CWA degradation products were also tested: **Phenarsazinic acid** ($DM_{[ox]}$), **Diphenylarsinic acid** ($DPA_{[ox]}$) **Phenyl-arsonic acid** ($PDCA_{[ox]}$) and **TPAO**.

All tests were performed on either third, fourth or fifth batch of *D. magna* individuals, clone “Bienennsee”, aged less then 24 hrs. Depending on the number of incubated organisms at each batch, a range from 5 to 9 tested concentrations per substance was arranged to fit the geometric series with a separation factor of 2,0. In every test at least 20 to 32 young daphnids grouped into 4 replications (from 5 to 8 individuals per vessel) were exposed to 100 ml of tested concentration or dilution water (controls).

All procedures were performed using proper scientific glassware to avoid adhesive effects of tested substances. Tests were performed under 16-hour light and 8-hour dark cycle in 21,0°C± 0,5°C.



TOXICITY THRESHOLDS

In total 35 successful aquatic acute toxicity tests have been performed. Both PDCA and Lewisite are by far the most toxic compounds among all tested arsine-based CWAs. On the other hand, Clark I and Adamsite are also very toxic (LC_{50} < 1 mg/L). There were no effects at maximum solubility (ca.4,5mg/L) in one replication of TPA, however when repeated, this compound turned out to be toxic (LC_{50} < 10 mg/L). AsCl3, with toxicity threshold above but around 10 mg/L, is “only” potentially harmful. None of the tested degradation products was toxic.

Studies confirm that most of organo-arsenic CWA parent compounds are toxic or very toxic in aquatic conditions, also, when compared with other xenobiotics. Therefore there is a high risk that at least in a local scale, the contaminated sediments and pore-waters can be toxic as for benthic infauna.

Czub, M, Kotwicki, L, Lang, T, Sanderson, H, Klusek, Z, Grabowski, M, Szubska, M, Jakacki, J, Andrzejewski, J, Rak, D & Beldowski, J 2018, 'Deep sea habitats in the chemical warfare dumping ares of the Baltic Sea' *Science of the Total Environment*, vol. 616-617, pp. 1485-1497

Test No. 202: Daphnia sp. Acute Immobilisation, 2012. OECD; https://www.oecd-ilibrary.org/