

STATE OF THE CHEMICAL MUNITIONS DUMPSITE IN THE LITHUANIAN ECONOMIC ZONE

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Large quantities of chemical munitions were dumped in the Baltic Sea after the World War II. In most cases the warfare was thrown onboard, either loose (bombs, shells, containers). Uncertainty still exists about the location of all dumping areas, the content and condition of the munitions or how they behave under the Baltic Sea conditions. In 2011 the project "Chemical Munitions Search and Assessment" (CHEMSEA) has been started. The CHEMSEA project seeks to close knowledge gaps on this topic by mapping and characterizing these dumping sites, to develop guidelines in order to reduce potential threats to the environment and fishermen and to prepare a region-wide contingency plan to deal with cases of leakage. In the frame of the CHEMSEA project scientific cruises were organized by project partners to the chemical munitions dumpsites in Bornholm Basin, Gotland Deep and Gdansk Deep. Poster presents the results of the sampling cruise to the part of the chemical munitions dumpsite in the Gotland Basin which lies within Lithuanian economic zone.

Methods

The sediment samples were collected during cruise of the scientific research vessel R/V Vėjušas in April 2013. Sampling stations at the dumpsite were chosen near I class objects according to sonar data obtained from scanning the seafloor by Swedish Maritime Administration (SMA). Sampling stations were also planned according to the results of previous research of the dumpsite in 2003 (Garnaga et al., 2006) (Fig. 1). Hydrological, hydrochemical and biological parameters were investigated. Sediment samples for arsenic and macrozoobenthos analysis were collected using a large Van Veen grab sampler (75 kg, with a sampling area of 0.1 m²) (Fig. 2). Sediment from the top 3-5 cm was sub-sampled and frozen immediately onboard (about -20°C). Conductivity (salinity), temperature, dissolved oxygen concentration in the water column were measured using CTD (Sea Sun Technologies). Water current speed and direction were measured using ADCP (RD Instruments). Every sediment sample was checked using portable ChemPro100i detector for the presence of chemical warfare agents (CWA) and other hazardous substances (Fig. 3).

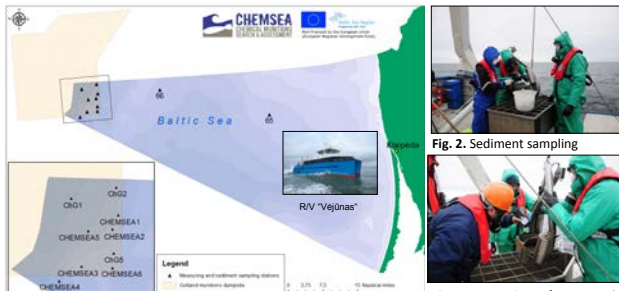


Fig. 1. Sampling stations and R/V "Vėjušas" (EPA)

Table 1. Characteristics of samples collected during the cruise to the Baltic Sea

Station	Coordinates	Depth	Sampling date	Dumping site	Type of bottom sediments	ChemPro 100i detector	
	Longitude	Latitude					
65	19°20.9'E	56°00.0'N	47	2013-04-26	NO	Coarse aleurite mud	Not detected
66	19°39.0'E	56°00.0'N	57	2013-04-26	NO	Fine sand	Not detected
CHEMSEA1	19°14.9'E	56°00.0'N	87	2013-04-27	YES	Coarse aleurite mud	Not detected
CHG1 (46)	19°08.8'E	56°01.2'N	117	2013-04-27	YES	-	-
CHG2-1	19°14.6'E	56°02.1'N	106	2013-04-27	YES	Coarse aleurite mud	Blister*
CHG2-2	19°14.6'E	56°02.1'N	106	2013-04-27	YES	Coarse aleurite mud	Not detected
CHEMSEA2	19°14.2'E	55°59.0'N	90	2013-04-27	YES	Coarse aleurite mud	Not detected
CHEMSEA5	19°11.1'E	55°58.8'N	101	2013-04-27	YES	Coarse aleurite mud	Not detected
CHG5	19°14.5'E	55°57.3'N	83	2013-04-27	YES	Coarse aleurite mud	Not detected
CHEMSEA3	19°10.4'E	55°56.2'N	85	2013-04-27	YES	Coarse aleurite mud	Chemical hazard**
CHEMSEA4	19°07.6'E	55°55.1'N	103	2013-04-27	NO	Coarse aleurite mud	Not detected
CHEMSEA6	19°14.4'E	55°56.2'N	78	2013-04-27	YES	Coarse aleurite mud with slight addition of fine sand	Not detected

*Blister - sulphur mustard (HD), lewisite (L), nitrogen mustard (HN).
**Chemical hazard - generic alarm for chemicals in hazardous concentrations or chemical mixtures

Results – Hydrology

In all stations (except 65 and 66) thermocline started at depth of 50 meters where temperature raised about +2°C. Surface temperature was 2,8-3,2°C, bottom temperature was 4,4-5,1°C. The largest difference between surface and bottom temperature was measured at station CHG1 - 2,3°C. At the CWA dumpsite surface salinity was 7,2-7,3 PSU, and bottom salinity was 9,4-11,4 PSU. The largest difference between surface and bottom salinity was measured at station CHG1 - 4,2 PSU. Halocline started at depth of 50 meters and from this depth salinity increased from 2,1 PSU to 4,2 PSU. Dissolved oxygen saturation in near-bottom water layer in all stations varied from 1,1 to 4,4 mg/l. Highest oxygen saturation in near-bottom layer was measured at stations 65 and 66 (9,5-10,8 mg/l). The lowest oxygen saturation in near-bottom layer was at station CHG1 - 1,1 mg/l. At CHEMSEA stations (1,2,3,6) and CHG (2,5) stations in near-bottom layer oxygen saturation was less than 2,6 mg/l (Fig. 4).

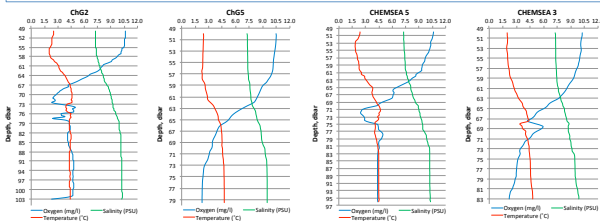


Fig. 4. Measured hydrological parameters (water temperature, salinity, dissolved oxygen) in water column

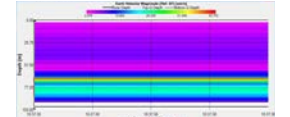


Fig. 5. Currents speed in water column at CHG2 st.

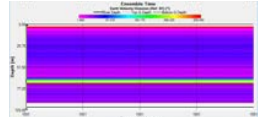


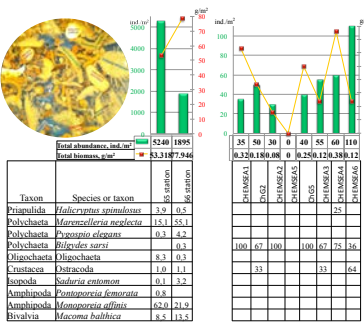
Fig. 6. Currents direction in water column at CHG2 st.

In the surface water layer at 1-10 meters depth, measured current speed was 4-6 cm/s. In the near-bottom layer current speed varied from 9 to 25 cm/s (Fig. 5). Maximum current speed was measured at CHEMSEA2 station - 75 cm/s. Current directions in all water layers were different. For example, at station CHG2 in water column current direction varied from 11 to 62 degrees (Fig. 6) and in station CHEMSEA3 current direction varied from 13 to 113 degrees. Almost at all stations currents were directed to north.

Methods – Macrozoobenthos

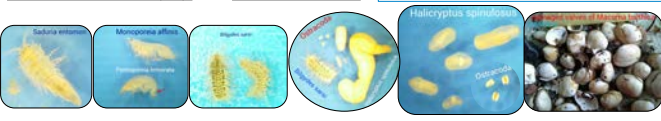
In total, 23 samples (2-3 per station) of the macrozoobenthos were taken during the expedition in 2013. Ship-board routines sampling (Van Veen grab - 75 kg, 0.1 m²), sieving (sieve 0.5 x 0.5 mm mesh size) and fixation (4 % formaldehyde) were done according to LST EN ISO 9391:2000, Manual for Marine Monitoring in the COMBINE Programme of HELCOM (Annex C-8). Laboratory routines: microscopic species identification (LEICA 12,5), wet weight (KERN 770-12).

Fig. 7. Total average abundance, biomass and abundance (%) of the macrozoobenthos species



At stations 65 and 66 in 47-55 meters depth in total 10 macrozoobenthos species were found (total average abundance - 1895-5240 ind./m², total average biomass - 53,32-77,95 g/m²) (Fig. 7).

Low species diversity, abundance and biomass were found in the deeper area at the chemical munitions dumpsite. Typical species *Halicryptus spinulosus* (Priapulida), *Bilgydes sarsi* (Polychaeta), *Ostracoda* (Crustacea), *Scoloplos armiger* (Polychaeta), *Diastylis rathkey* (Cumacea), *Mysis mixta* (Mysidacea), *Saduria entomon* (Isopoda), *Monoporeia affinis* (Amphipoda), *Pontoporeia femorata* (Amphipoda), *Macoma balthica* (Bivalvia) were used to be found in the dumpsite area in 1981-1993. In 2013 only *Halicryptus spinulosus*, *Bilgydes sarsi* and *Ostracoda* were found in 78-106 m depth. Total average abundance was 0-110 ind./m², total average biomass - 0,0-4 g/m² (Fig. 7).



Large heaps of damaged valves of *Macoma balthica* were found in 85 m (CHEMSEA3) depth, but no one was alive.

Results – Arsenic (As)

Arsenic concentration in sediments as an indicator of contamination by chemical warfare agents was assessed. As in sediments was determined in the Laboratory of Geoenvironmental Research, Nature Research Center, by ICP MS. As data are plotted in Fig. 8. The concentration of As in the sediments ranged from <1.9 to 15.9 mg/kg. As and iron (As:Fe) relationships has been used to assess the extent of arsenic pollution. An approach is based on calculating the residuals about the regression line. The residual is the difference between measured concentration and that calculated from the regression equation (Whalley et al., 1999; Garnaga et al., 2006). As as a function to Fe is shown in Fig. 9. As residuals are plotted for the various stations (Fig. 10). Large positive residuals may be regarded as representing samples with higher than expected As concentration. There are slightly higher concentrations in three samples from the chemical munitions dumpsite, notably at station CHG2-2. Chem Pro100i detector detected Blister substances in the same sample (Table 1).

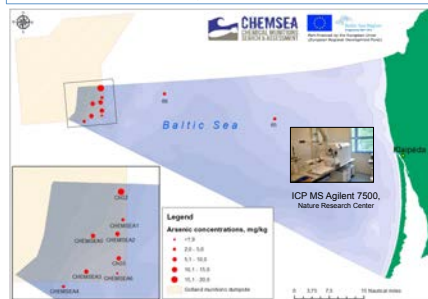


Fig. 8. Arsenic concentrations (mg/kg dry weight) in the surface sediments of the Lithuanian economic zone

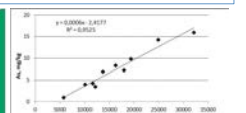


Fig. 9. Correlation between Fe and As in the Baltic Sea sediment

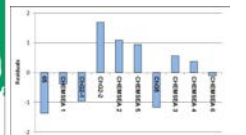


Fig. 10. Residual arsenic normalized to iron

Conclusions

- Measured values of hydrological parameters were close to long-term averages. The lowest dissolved oxygen concentration at the near-bottom water layer was 1,1 mg/l (CHG1 station). At CHEMSEA stations (1,2,3,6) and CHG (2,5) at near-bottom layer oxygen saturation was less than 2,6 mg/l. In the near-bottom water layer current speed varied from 1 to 75 cm/s. Almost at all stations currents were directed to north.
- Macrozoobenthos organisms were found in all the studied stations except CHEMSEA5. During the research period 1981-1993, 10 macrozoobenthos species were found in 78-110 m depth. In 2013 only *Halicryptus spinulosus*, *Bilgydes sarsi* and *Ostracoda* were found in 18 samplers.
- Normalization of results to iron showed slightly elevated residual arsenic concentrations at some station of the dumpsite, notably at station CHG2-2. Arsenic concentrations in sediments of the chemical munitions dumpsite (<1.9 to 15.9 mg/kg) are in line with the concentrations found during previous study of the dumpsite in 2003 (2.1 to 19.0 mg/kg).
- Studied parameters did not show any drastic changes of the environment at the chemical munitions dumpsite comparing to previous research, although the number of the macrozoobenthos species has decreased notably.