15. CHEMICAL WEAPONS DUMPED IN THE BALTIC SEA

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15.1. Introduction

Chemical weapons (CW) use toxic properties of chemical substances to kill, injure or incapacitate an enemy during warfare. Chemical weapons are classified by the United Nations (together with nuclear and bacteriological weapon) as weapons of mass destruction.

Chemical weapons include both chemical munitions (e.g. bombs, shells, grenades) and chemical warfare agents. Chemical warfare agents may be in liquid, gas or solid form. Liquid agents are set to be volatile (high vapor pressure) so they can be dispersed over a large region quickly. Solid (mostly plasticized) form is used rarely.

15.1.1. SHORT HISTORY OF USE OF CHEMICAL WEAPONS

Toxic properties of some natural agents were known and used as early as the stone age (e.g. toxic arc arrows). There were also attempts to use toxic compounds (mainly as smoke and fumes) against enemy in various ancient battles (e.g. by ancient Chinese and ancient Greeks). During the course of later centuries AC, toxic agents were sometimes used in wars and battles, but it is worth noting that battle commanders often considered these as "perfidious and odious" weapons and refused to use them.

The first full-scale deployment of a chemical warfare agent, chlorine gas, was during the World War I, in the battle of Ypres (15 July, 1915) by the Germans to attack French troops (Figures 1 and 2). The use of chlorine gas caused 5000 death and 15,000 wounded cases. Two years later in 1917, also near Ypres, mustard gas (2,2′-dichloro-diethyl sulphide) was used (see also: http://www.firstworldwar.com/battles/ypres3.htm). From that time mustard gas was mostly known as *Yperite*. During the course of the whole World War I, there were 85,000 death causalities and 1,176,500 wounded by chemical warfare. (see also http://en.wikipedia.org/wiki/Chemical_warfare)

After Word War I, the possible use of chemical weapons had become deep fear in the minds of most people at that time. In 1925, sixteen of the world's

I. E. Gonenc et al. (eds.), Assessment of the Fate and Effects of Toxic Agents on Water Resources, 301–321.

Figure 1. Chlorine gas released at Ypres. http://www.tau.ac.il/~pet/html/history2.html

major nations signed the Geneva Protocol, pledging never use gas or bacteriological methods of warfare, however chemical agents were occasionally used to subdue populations and suppress rebellion. In 1922–1927, combined Spanish and French forces dropped mustard gas bombs in Morocco. In 1935, Italian Fascists used mustard gas in Ethiopia causing 15,000 casualties mostly from mustard gas.

During the World War II, the German Nazis developed and manufactured large quantities of old and new chemical agents, but chemical warfare was not used on a large scale by either Germans or Allies. However, the German Nazis

Figure 2. Chlorine gas attack. www.home.zonnet.nl/rene.brouwer/usa/usa.htm. *See also* www.eyewitnesstohistory.com/gas.htm and http://www.firstworldwar.com/photos/graphics/cnp_gas_aeroplane_01.jpg

used the insecticide Zyklon B to kill large number of victims in concentration camps. During the course of World War II, the Japanese used mustard gas against Chinese troops.

After World War II, enormous resources were spent by the USA to develop nerve agents (known as "V-Series" nerve gases). During the 1960s, the US explored the use of incapacitating agents and defoliant agents in Vietnam. Very little information was available about developments of Soviet chemical weapons, however during the Gorbatchev time it was published that highly toxic agents were developed in Soviet Union in large amounts (Surikov, 1996; Wikipedia, 2006).

After the World War II, in Iran-Iraq war, about 100,000 Iranian soldiers were victims of Iraq's chemical attack, mostly hit by mustard gas. About 20,000 Iranian soldiers were killed by nerve gas. In 1998 Iraqi Kurdish were exposed to multiple chemical agents, which killed about 5000 people.

All in all, about 70 different chemicals have been used or stockpiled as Chemical Weapons (CW) during the whole 20th century. At present, their production and stockpiling is outlawed by the Chemical Weapons Convention (CWC, 1993).

15.1.2. CLASSIFICATION AND PROPERTIES OF CHEMICAL WARFARE AGENTS

There are different classifications of chemical warfare agents; however the most often they are classified according to the health effects:

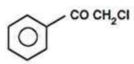
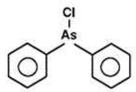
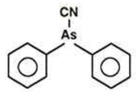
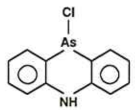
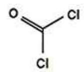
- Tear gases (lachrymators): Chloroacetophenone.
- Nose and throat irritations: Clark I, Clark II, Adamsite.
- Lung irritations: Phosgene, Diphosgene.
- Blister gases (vesicants): Sulphur Mustard, Nitrogen Mustard, Lewisite.
- Nerve gases: Tabun.
- Additives, such as monochlorobenzene (are made to the warfare agents in order to change their physico-chemical properties.

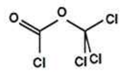
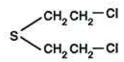
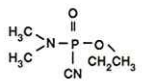
Chemical warfare agents are usually highly toxic chlorinated aromatic and/or aliphatic compounds. Some properties of selected agents are given in Table 1.

15.1.3. CHEMICAL WARFARE AGENTS IN THE MARINE ENVIRONMENT

The behavior of warfare agents in the marine environment depends on physical–chemical properties of the substances and external/environmental factors: temperature, salinity, pH value and turbulence in water. For degradation of chemical warfare agents dissolution in water is the first and the most

TABLE 1. Chemical structures and physical–chemical properties of the chemical warfare agents (HELCOM CHEMU, 1994)

Name	Synonyms	Structure	Melting point (°C)	Boiling point (°C)	Vapor pressure (mmHg) 20 °C	Density (g/cm^3)	Aqueous solubility (g/l)
Tear agents							
Chloroacetofenone (2-chloro-1-fenylethanone)	CN, Mace		54–56	244	0.013	1.32	1
Nose and throat irritants							
Clark I (diphenyl arsine chloride)	Sternite		38–44	307–333	0.0016	1.422	2
Clark II (diphenyl arsine cyanide)	Sternite		30–35	290–346	0.000047	1.45	2
Adamsite (10-chloro-5-hydrophenarsazine)	Phenarsazine chloride		195	410	2×10^{-13}	1.65	0.002
Lung irritants							
Phosgene (carbon dichloride oxidate)	Carbonyl chloride, CG		−128	7.6	1178	3.4	9

Diphosgene (trichloromethyl chloroformate)	Perstoff		−57	127	10.3	1.65	
Blister gases (vesicants)							
Mustard gas (2,2′-dichloro-diethylo sulfide)	Yperit Lost Senfgas		14	228	0.72	127	0.8
Viscous mustard gas		Different mixtures, e.g. 63% mustard gas + 37% Lewisite					
Nitrogen mustard gas tri-(2-chloroetylo) amina	Trichlormethin	$N(CH_3CH_2Cl)_3$	−4	235	0.011	1.24	0.16
Lewisite (2-chlorowinylo-dichloroarsyna)	L	$Cl_2AsCH{=}CHCl$	−18	190	0.35	1.89	0.5
Nerve gases							
Tabun (P-cyano-*N*, *N*-dimethyl phosphonamid acid ethyl ester)	Trilon 83		−50	246	0,07	1.07	120

important step. As regards solubility, the reaction of chemical warfare agents with water depends on hydrolysis. This process leads to formation of new compounds with properties different from those of the chemical warfare agents. During this process they lose properties of warfare agents as they decompose to non-toxic and/or less toxic compounds. Table 2 presents selected examples of results (in simplified manner) of degradation processes in sea water.

15.2. Chemical Ammunition

15.2.1. CLASSIFICATION OF CHEMICAL AMMUNITION

Chemical ammunition produced during the World War II in Germany was in the form of:

- Aircraft bombs;
- Artillery shells;
- High-explosive bombs;
- Mines;
- Encasements;
- Smoke grenades.

Some warfare agents (e.g., Cyclon B) were kept in metal containers.

15.2.2. DUMPING THE CHEMICAL WEAPON IN THE WORLD OCEAN

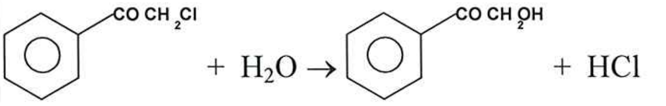
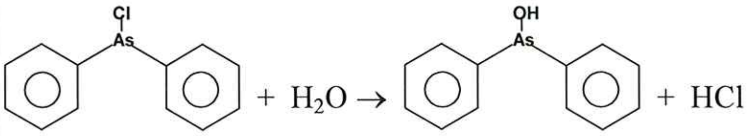
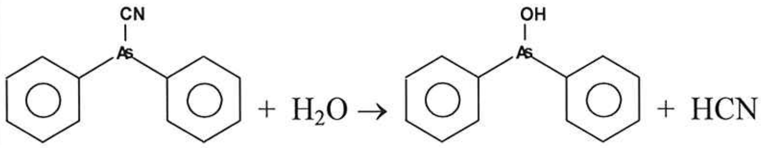
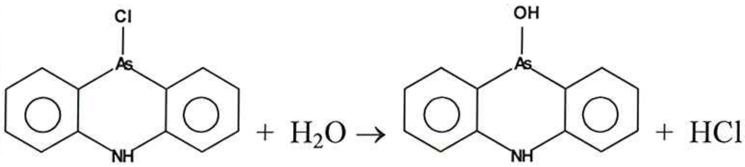
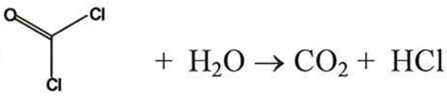
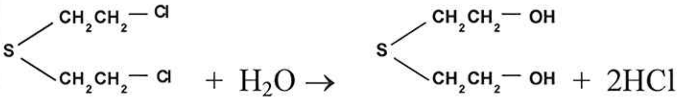
Utilization of large quantities of CW on land is very expensive and in fact inoperable. Some smaller quantities of warfare agents can be utilized on military polygons with chemical treatment. Incineration of CW is also expensive and causes other problems, such as toxic fumes. Storage on land is not safe and expensive. The best choice (the most safe and operable method) seems to be to dump CW at sea. This "best" choice has lead to problems for us and for future generations (NATO ASI Series, 1995).

There is sufficient evidence that almost all oceans and seas were used for dumping chemical and/or convention ammunitions. Some of the dumping sites are well known and documented. However, some of them are still hidden in archives of marine military operations. Figure 3 shows the main dumping areas (marked with dots) in the world ocean (Otremba, 2006)

15.2.3. CHEMICAL WEAPON DUMPED IN THE BALTIC SEA

After the World War II, allies found in Germany about 300 thousand tonnes of chemical weapon. Some part of this weapon was taken by Allies for storage, and the rest was dumped in Skagerrak and the Baltic Sea.

Table 15.2. Simplified formulas of chemical degradation (hydrolysis) of warfare agents in sea water

 **Chloroacetophenone** (2-Chloro-1-fenylethanon) after slow hydrolysis (dehalogenation) in sea water produces non toxic compounds. Hydrogen chloride reacts further to sodium chloride
 **Clark I** (diphenylochloroarsine) hydrolyses to a less toxic product, difenyloarsenios acid (which has no features of warfare agent) and hydrochloric acid. Toxic arsenic compounds are stable, however the will be diluted/dispersed in the marine environment
 **Clark II** (Diphenylcyanoarsine) hydrolyses to diphenylarseniuos oxide and hydrogen cyanide. Toxic hydrogen cyanide is not stable in the marine environment and transforms further to formic acid and salts of formic acid
 **Adamsite** (diphenyl-amino-chloro-arsine) slowly dissolves and hydrolyses in sea water. The final product will contain arsine
 **Phosgene** (carbonylchloride)transforms to non harmful substances
 mustard gas thiodiglicol **Mustard gas** (dichlorodiethyl sulfide) in water slowly hydrolyses and forms thiodiglicol and hydrochloric acid. Both final products are non-toxic

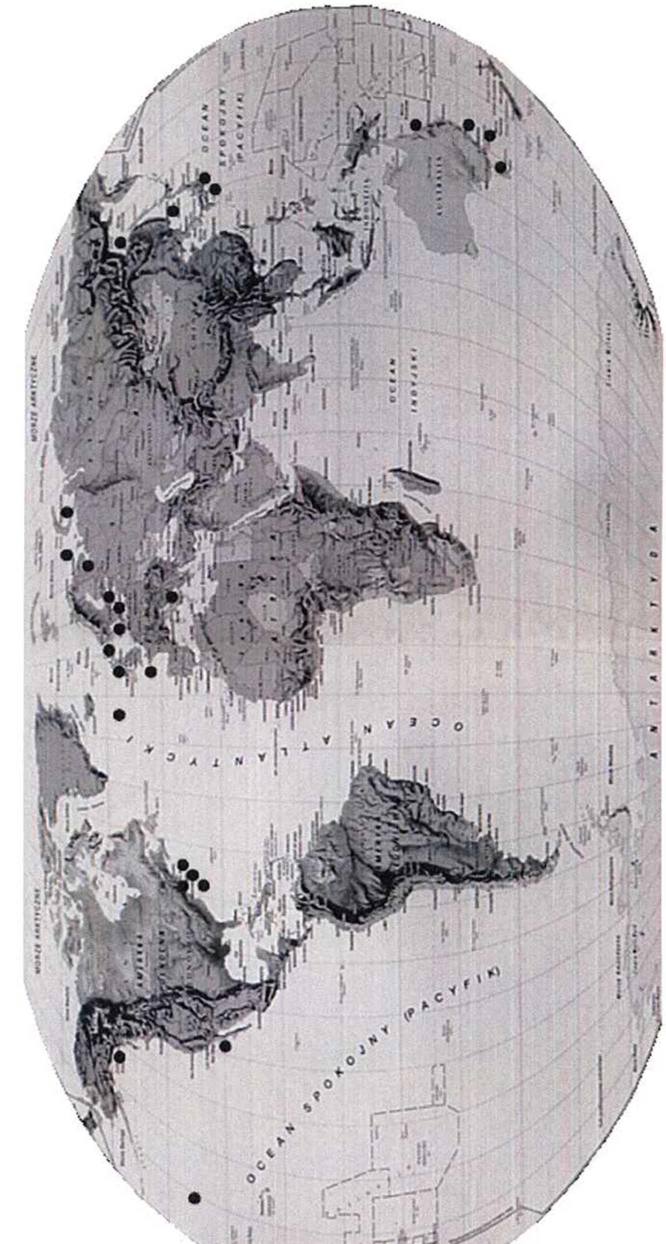


Figure 3. Dumpsites in global oceans (Otremba, 2006)

Figure 4. Dumping operation in the Beaufort Dyke (Irish Sea). The same dumping "technique" was used in the Baltic Sea http://www.manxman.co.im/cleague/archive/bombs.html

There were two different methods of dumping: throwing overboard (Figure 4) which was done in the Baltic and sinking in old ships (Figure 5), which was done in the North Sea (Skagerrak).

Altogether about 65 thousand tonnes of chemical weapon was dumped in the Baltic Sea (Figure 6) in form of: artillery shells, aircraft bombs (Figure 7), mines, smoke grenades, encasements, containers, drums. This is equivalent to about 13 thousand tonnes of toxic chemical agents: chloroacetophenone, clark I, clark II, yperite, phosgene, adamsite, lewisite, tabun (HELCOM CHEMU, 1994). However, there were cases of throwing munitions overboard during the transport to dumpsites.

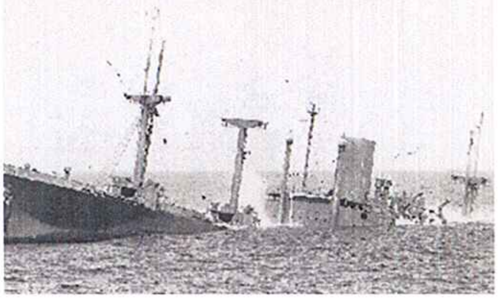


Figure 5. Sinking old military ship loaded with CW (US archives). This technique was used in the North Sea (Skagerrak)

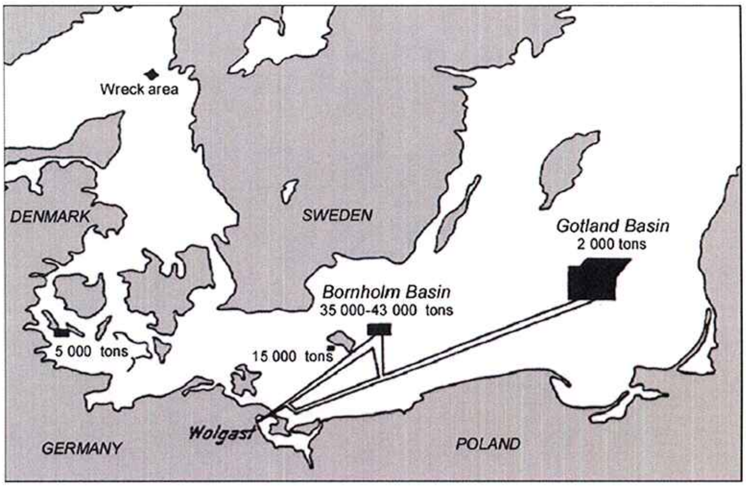


Figure 6. Known dumping areas in the Baltic Sea (HELCOM CHEMU, 1994)

15.2.4. IMMEDIATE EFFECTS AFTER DUMPING

Following the dumping operations of chemical ammunitions, there were numerous findings of CW on beaches of the Southern Baltic Sea and many cases of serious injuries (including injuries of children) in Sweden, Germany, Poland and Denmark (Andrulewicz, 1996; Glasby, 1997; Kantolahti, 1994).

Figure 7. Handling of corroded chemical bomb (Fiskeri Arbogen, 2000)

Figure 8. Picture of chemical weapons obtained by ROV during the Russian studies in the Bornholm Basin (Paka and Spiridonov, 2002)

More than fifty years after the dumping took place, such incidences on beaches are not recorded, however, they cannot be excluded (Korzeniewski, 1994).

Dumped CWs are probably partly buried in sediments, partly lying on sediment surface and therefore still visible (Figures 8 and 9).

Dumpsites in deep basins of the Baltic Sea are mostly under anoxic conditions, with the rate of sedimentation approximately 1 mm/year. Due to trawling operations some unknown part of chemical munitions has been redistributed on large parts of sea bottom. Over time, the brackish water of the Baltic Sea causes the shell castings/metal covers to corrode (Figures 8 and 9) and

Figure 9. Picture of chemical weapons obtained by ROV during the Russian studies in the Bornholm Basin (Paka and Spiridonov, 2002)

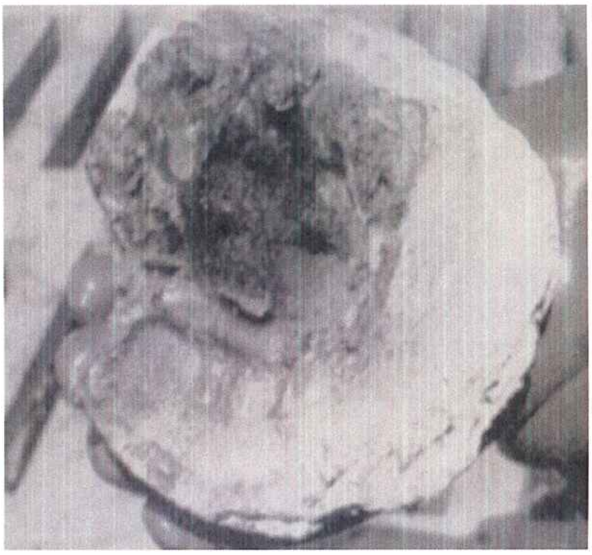


Figure 10. Lump of yperite caught by fisherman in the Baltic Sea (Fiskeri Arbogen, 2000)

release chemical agents to marine environment. Due to hydrolysis, chemical agents are transformed to non toxic or less toxic compounds. However, they are some suspicions that yperite may be transformed to wax-like (sometimes resembling amber) solidified form. This form is presumably stable at sea bottom conditions, even though in this form, the agent is active enough to cause severe contact burns to anybody touching it (Figures 10 and 11).

Figure 11. After contact with yperite (Fiskeri Arbogen, 2000)

15.3. Selected Cases of Contacts with Chemical Munitions in The Baltic Sea Area

15.3.1. INJURIES OF CHILDREN, 1955

In July 1955, children from an organized summer holiday were playing on the beach of the southern Baltic Sea. They found a barrel and rolled it along the beach. After 30 minutes, the first skin burning symptoms appeared. All in all, 102 children suffered skin burns and four suffered severe injuries to their eyes (Korzeniewski, 1994). The agent causing this effect was never identified.

15.3.2. INJURIES OF FISHERMEN, 1997

In January 1997, the Polish fishing cutter WŁA-206 was trawling for cod and flatfish within fishing rectangle R-9 of the Polish Economic Zone, about 18 miles north off the Polish coast (approximate position 55°12′N; 18°38′E). Fish were collected into containers, but a substance resembling clay (estimated as 5–7 kg) was left on deck. This lump was dumped in a port rubbish container and finally brought to the city scrap yard. The next day, all of the fishermen experienced adverse skin reactions, a sort of burning sensation, skin lesions and reddening. Most of the doctors diagnosed these burns as caused by an unknown substance. After examination, this substance was identified by the navy experts as yperite.

A specialized chemical division of the Polish Navy decontaminated the fishing vessel, the area around the rubbish container and the road connecting the port and the disposal site. The toxic "clay-looking lump" was found and decontaminated on a military polygon; afterwards a sample was taken for chemical analyses. Four fishermen were hospitalized due to severe skin burns and released home after few weeks, another four were medically treated and home released.

15.4. Research on Dumped Chemical Weapon in The Baltic Sea

The Working Group on Dumped Chemical Munitions (HELCOM CHEMU, 1994) issued several recommendations. Out of thirteen recommendations, four were related to the need of research on chemical munitions.

1. Regarding verification of existing official dumping sites: *"search for location of chemical munitions could be conducted on national basis."*
2. Related to investigations on the chemical processes and ecological effects of warfare agents: *"further investigation on these processes and effects,*

especially on poorly soluble compounds such as viscous mustard gas and arsenic compounds, should be undertaken."

3. Related to the state of chemical weapon—after more than fifty years on sea bottom: *"investigations on these issues should be carried out in selected parts of the dumping areas."*
4. Related to field investigations on selected dumping areas: *"investigations including water, sediment and biota should be conducted in selected dumping areas."*

Following HELCOM recommendations, two field studies were organized—by Germany—mainly on transport routes of CW (HELCOM, 1996a, 1996b) and by Russia mainly in the Bormnholm Basin (Paka, 2001; Paka and Spiridonov, 2002; Paka, 2004). There were also some laboratory studies in Denmark, Poland, and Sweden.

15.4.1. RESULTS OF GERMAN STUDIES, 1994–1996

In 1996, Germany presented preliminary results of studies taken by the German Hydrographic Service (HELCOM, 1996b). They were based on magnetometric and hydroacoustic surveys (side scan sonar, high resolution sonar) within the German part of the Baltic transport routes from port Wolgast to CWs dumping area located east of Bornholm. The following findings were reported for transport routes across 4000 nautical miles:

- 900 magnetic anomalies (7 very large anomalies-like ship wrecks; 50 big anomalies-like bombs on the sediment surface; 130 significant anomalies-like bombs covered by sediments.
- 30 other anomalies (most of the anomalies were found on transport routes and on the Odra Bank).
- 1300 contacts by side scan sonar (550 could be a natural objects, e.g. stone reefs).

After the above studies, there was proposed continuation of the research by a remotely operated vessel (ROV); however, there is no information about possible results.

15.4.2. RESULTS OF RUSSIAN RESEARCH, 2001

Russian studies by the Institute of Oceanography in Kaliningrad on dumpsites were performed in 1994–1995 (HELCOM EC MON, 1996; HELCOM, 1996a) and in 1998–2001in the Gotland Deep, Bornholm Deep and Kattegat (Paka, 2001) (Figure 12). They were related to evaluating contamination of sediments in dumpsites (Figure 13) and collecting bottom documentation by ROV. These studies showed a considerable rate of corrosion of chemical

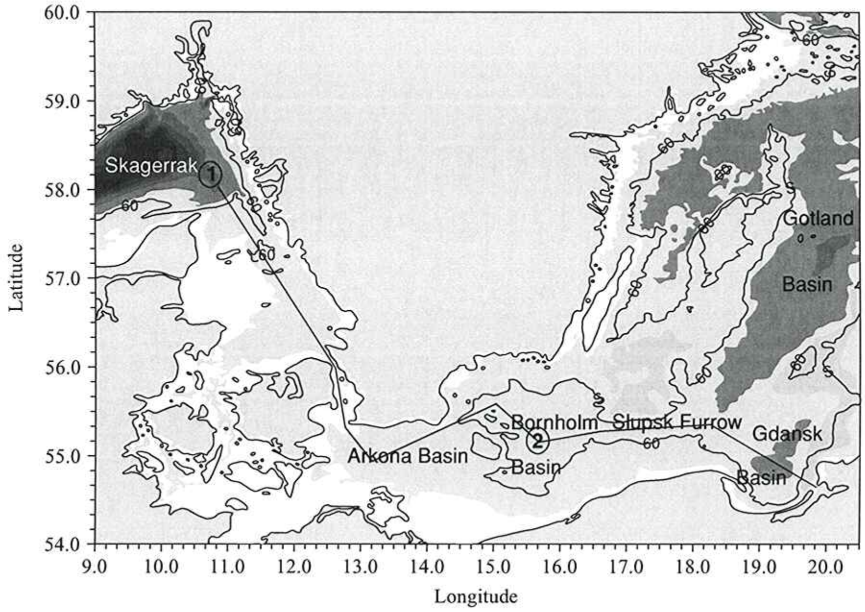


Figure 12. The Russian studies on dumpsites of the Baltic Sea (Paka, 2001)

weapons (Figures 8 and 9), as well as the contamination of sediment dump sites by arsenic.

15.4.3. RESULTS OF STUDIES IN OTHER COUNTRIES

Polish studies were performed following the catch of lump of yperitre by Polish fishermen in February 1997. These were laboratory analyses of chemical composition of yperite lump. Thin layer chromatography and gas chromatography

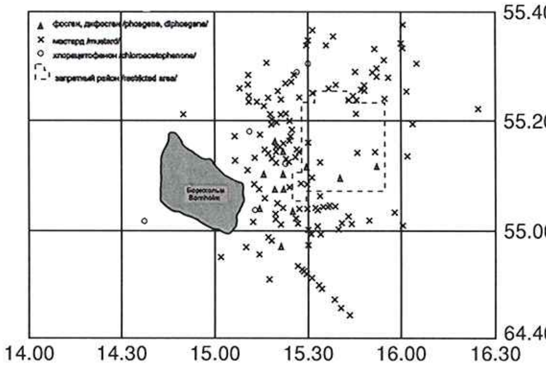


Figure 13. Sediment sampling sites in Bornhom Basin (Paka, 2001)

coupled with mass spectrometry and atomic absorption spectrometry were applied (Technical Military Academy in Warsaw). There was found 20 toxic compounds of different toxicity in the lump of yperite (Witkiewicz, 1996).

Sweden reported having detected mustard gas at sea (Granbom, 1996). The highest concentration of mustard gas agent (119 ppt) was found in a sediment sample one kilometer away from a wreck containing chemical munitions in the Skagerrack. Denmark informed HELCOM about their methodology for determination of physio-chemical parameters of selected organoarsenic species (HELCOM EC 6/9/2, 1995).

15.4.4. NEW/ONGOING RESEARCH PROJECTS

In 2005–2006, EU established a research project on "Modeling of Ecological Risk of Sea dumped Chemical Weapons (MERCW)" (Project manager: Dr. Vadim Paka, Shirshow Institute of Oceanography in Kaliningrad). Project objectives were:

- To develop hydro chemical, hydrographical and hydro biological investigations;
- To evaluate model of the release, migration and degradation of toxic chemical agents;
- To develop regional ecological risk assessment model.

Recently, Russia has established a monitoring programme on Baltic dumpsites that will be carried out by AtlantNIRO and Shirshov Institute of Oceanology in Kaliningrad (Paka, 2006).

15.5. Lessons Learned from Unintentional Human Contact with Dumped Chemical Munitions

A brief summary/recapitulation of events recorded at a scoping session at the Marine Court after bringing a lump of warfare agents into the city of Władysławowo (Poland) (1997) is described below:

- A series of unforeseen events may lead to an accident, even if there is sufficient awareness about dumped chemical weapon at sea.

  The fishermen from Polish fishing cutter caught a lump of substance resembling clay and left in deck due serious engine problems, low air temperature and rough weather. Under "normal" circumstance, the lamp of clay looking substance would have been washed out at sea.

- It was never before described that a lump of dangerous material may look like ordinary, safe material.

  The physical and chemical properties of elasticized (non-gas) yperite remaining on the sea-bed may change to such a degree that it cannot be easily distinguished from other naturally occurring items, such as clay or amber.
- Adverse effects may happen even without having direct/physical contact with the warfare agent.

  The fisherman who took and disposed the lump of yperite was not as badly affected as were others who had not even see it. Those fishermen severely affected by yperite came into contact with a towel/cloth which was previously used to clean some traces of dirt.
- The effects of warfare agent will depend on outside air conditions, particularly air temperature.

  Negative effects were limited to physical contact with the dangerous substance due to the extremely cold air temperature—approximately −20 °C. At higher temperatures, the effects of contact with yperite could be much more serious—similar to that occurring from its use as a weapon.
- Chemical warfare agents in the Baltic Sea are not only found within the official dumpsites.

  Fish trawling did not take place within or near known dump sites or along transportation corridors. Present information regarding the location of dumped chemical munitions is inadequate to make firm estimates regarding where munitions are most likely to be found.

15.6. Designing Research on Dumped Chemical Weapon

Not many studies were performed on CWs until now (although some unpublished military research may exist). It is not because of lack of interest and/or low level of importance. These studies are simply expensive, difficult to perform, and require modern techniques that were not always available. This study can be dangerous and therefore it is not for just "ordinary scientists." Warfare agents or corroded ammunition must be handled by special military units.

Field investigations: Field survey for dumped CW will involve typical sea bottom mapping techniques:

- precise positioning system by digital global positioning system (DGPS);
- magnetometric techniques for detection of metal objects/magnetic anomalies (e.g. proton magnetometer);

- acoustic techniques: echo sounding (e.g. high resolution side scan sonar including automatic data processing) side-scanning, sub-bottom profiling and/or multibeam scanning;
- video techniques for field inspection and documentation, usually applying Remotely Operated Vessels (ROVs);
- bottom sediment sampling techniques for analysis of CW traces and/or their metabolites (e.g. arsenic compounds). It may be used standard sediment sampling (e.g. gravity corers). Sediment sampling may already require special safety conditions;
- analyses of fish and bottom macrofauna for CW traces.

The above-mentioned approach will allow the identification of metallic objects, and in addition, it will help to identify which objects are chemical munitions. In the case of identification of chemical munitions, decisions will have to be made as to whether or not to bring the warfare item to the surface.

Laboratory investigations: Lifting of warfare items from the bottom (e.g. for laboratory studies) can only be done when safety conditions are assured. Safety on board during sampling, handling and transport of samples to research laboratories will require military chemistry specialists. Research on actual items/samples recovered from the sea bottom will include the following analyses:

- rate of corrosion of metal walls;
- analyses of sediments for possible contamination by toxic warfare agents;
- products resulting from aging (hydrolyses and polymerization) of chemical munitions on sea-bed (by Gas Chromatography/Mass Spectrometry);
- sediment analysis for arsenic content (Atomic Absorption Spectrometry);
- toxicity tests.

The use of results: These studies will be useful for various reasons:

- Precise determination of the areas with dumped chemical munitions.
- Preparation of revised navigational charts for fishermen and others working on sea bottom.
- Determination of present status of CWs.
- Sea bottom mapping for growing demand of exploitation of sea bottom for minerals and different sub sea transmission lines.
- Comprehensive assessment of the potential threats posed by chemical munitions to the marine environment and human activities performed at sea (fishery, exploitation of mineral resources, cable laying and others).

- Recommendations on monitoring methods which will allow control of potential threats resulting from corrosion and chemical reactions of toxic warfare agents dumped at sea.
- Updating of guidelines for fishermen on how to recognize and deal with chemical munitions which have been accidentally brought on board with trawl catches.
- Preparing comprehensive plan defining which authorities and in what manner to deal with incidents where chemical munitions have been caught by fishermen, as well as how to avoid possible contamination of fish products with toxic warfare agents.

15.7. Conclusions and Comments

The following comments related to dumped warfare agents can be drafted:

- There is no realistic/practical possibility to utilize chemical weapon dumped in the Baltic Sea (and other seas) neither on sea bottom nor on land. Therefore present and future generations will have to leave with this "gift" from previous generations.
- There is an evidence that part of CW is corroded and hydrolyzed but some part will most probably stay there for hundreds of years (e.g. yperite in plasticized form).
- Massive ecological and human disaster due to duped CW is unlikely. Local danger will appear when chemical weapon is lifted from the sea (accidentally or intentionally) during bottom trawling, touching it on the sea bottom or when stranded on the beach.
- There is a need for specific instructions about how to avoid contacts with chemical weapon and/chemical warfare agents, and/or or how to handle war items in case they are brought from the sea bottom. There is also needed to elaborate a rescue operation scheme in case of accidents with CW.
- There is a need for improvement of public awareness in case war items will appear on the beach.
- There is a need for further research on dumpsites, present status of CWs and chemical transformation under marine conditions.
- The HELCOM "Report on Chemical Munitions Dumped in the Baltic Sea" was issued over ten years ago, so the report and recommendations should be revised and updated.
- The presence of CWs on the sea bottom is a serious obstruction for bottom constructions (oil and gas lines, high voltage power cables, windmill parks) and any kind of bottom trawling.

- Chemical weapons dumped at sea should be seriously considered by anti-terrorists measures. For many terrorist organizations, CWs might be considered an ideal choice for a mode of attack: CWs are cheap, relatively accessible, and easy to transport. Fortunately, the efficient use of CW on large scale is not easy.

There are some examples of use or attempted use of chemical agents by terrorists. The most well known is the case of March 20, 1995, when an apocalyptic group based in Japan that believed it is necessary to destroy the planet, released sarin into the Tokyo subway system, killing 12 and injuring over 5000 people.

Human medical treatment will depend on the type of CW used. The general rule is to escape towards fresh air and, if possible, to use oxygen as a breathing medium. In case of skin contacts with blister gases (yperite, lewisite), it is always necessary to wash-out injured area with plenty of water and, if available, a solution of chloramine.

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