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# INVESTIGATION, MAPPING, AND LOCATION OF DUMPED AMMUNITION. A PROJECT OF THE SWEDISH ARMED FORCES

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## ABSTRACT

Old ammunition and explosives have been dumped in the Baltic Sea, small lakes, and depleted mines up to 1965. So far, the Swedish Armed Forces have mapped 106 different dump sites, most of them in lakes (75) and in the Baltic Sea (25). The locations are spread all over the country. When the Armed Forces started this project, the purpose was to:

- find the exact location for each dumping;
- investigate the risks for the environment and decide what sort of environmental influence is possible in the future;
- assess the likelihood of spontaneous combustion;
- explore the possibilities of salvaging the ammunition, if
- needed.

A short summary of the results of our investigations and tests is:

- there are no good methods to locate ammunition buried in the bottom sediment of the sea;
- dumped ammunition is not harmful to the environment;
- there is no risk of spontaneous combustion as long as you do not move the ammunition;
- there is no reason, from an environmental point of view, to salvage dumped ammunition.

## INTRODUCTION

Old military ammunition and explosives have been dumped in both freshwater, seawater and old mineshafts up to 1965. Up to now we have mapped 106 different locations most of them in small lakes (75), the Baltic Sea and the west coast of Sweden (25). The locations are spread all over the country. When we started the studies on dumped ammunition approximately 10 years ago the fate and effects of the dumping was unknown. Even the exact location was vague sometimes.

The aim of our study was to:

1. find the exact locations for each dumping;
2. investigate the risks for the environment and decide what sort of environmental influence we can get in the future;
3. investigate the possibility of spontaneous combustion;
4. explore the possibilities of salvage the ammunition if needed.

## EXACT LOCATION

It is very difficult to find the exact location of the dumped ammunition both in the sea and the lakes in spite of written information, sea charts, maps or other paper where the dumping area is pointed out. This is because of the bottom layer. If the bottom consists of sand, mud, silt and so on, the ammunition will sink down to solid ground and hence are buried in the sediment. In such cases you cannot detect the ammunition with standard methods: sonar, video camera, divers and so on. When the ammunition is buried in the sediment there are no methods to locate the dumping location.

In small lakes it is a little bit easier since we can use ground radar, electromagnetic equipment to detect a target which could be ammunition. After that we must identify the target to be sure it is ammunition and not a cray pot, fish trap or bicycles or anything else made of metal. We have developed a very simple method. We sluice away the sediment around the target with water under high pressure and steer the water tube/hosepipe with a video camera. I can tell you that we have found a lot of metal scrap when we were searching for ammunition. As you can understand this is a time-wasting and sometimes dirty job and up to now we have only investigate 50 % of the lakes and 25 % of the dumping places at sea.

## SPONTANEOUS COMBUSTION

We have tested and examined the possibilities of spontaneous combustion and the result is that there are no risks as long as you do not move the ammunition.

There is a risk that explosives and other organic and inorganic compounds from the ammunition may, if the compounds are water-soluble, pollute and casue serious damage to the environment.

The most harmful substances are trinitrotoluene (TNT) and hexogen (RDX) and/or their degradation products which are toxic to aquatic organisms at low concentrations.

Heavy metals in small quantities, copper, brass and mercury can be found in metal parts of ammunition and fuse bodies but the amounts of these heavy metals are so small that they will probably not effect the environment. Most of a shell consists of iron.

In co-operation with the Defence Research Establishment (FOI) in Umeå and the University of Göteborg, the Armed Forces have tested the risk for environmental contamination. FOI has studied the behaviour of TNT in soil and groundwater under natural conditions and found that TNT will adsorb to the soil. The amount of adsorption will depend on natural conditions at the site. FOI has also analysed sediment and water from different dumping locations and has not found any traces of TNT in the mud. Perhaps this is due to the fact that TNT is enclosed in the shell and the surrounding metal, even after 40-60 years, has not rusted away, meaning that the TNT has no contact with the water or the sediment

FOI and The University of Uppsala have performed an environmental risk assessment of four selected lakes with dumped ammunition. The results indicate that sediments of many lakes today are heavily contaminated but the contamination cannot be coupled to the dumped ammunition but instead originate from other sources. It is concluded that there is no leakage of explosives from ammunition today and over a short timeframe, dumped ammunition is not an environmental threat.

In the longer term, perspective lakes with a high sedimentation rate will run a lower risk of future environmental impact. In such lakes, the surrounding sediment will retain explosives, probably irreversibly. It can not be excluded however that smaller lakes with very high amount of dumped ammunition and lower sedimentation rate may run a higher risk.

Lake/freshwater and sea/saltwater environments are substantially different. Therefore FOI has mimicked leakage of TNT in a sea environment. Sediment and water from three different sea dumping locations were collected. From the Baltic Sea, one location with aerobic and one location with anaerobic sediment were selected. From the west coast, only one aerobic sediment location was chosen.

The result of this study showed that TNT was rapidly transformed to other metabolites also in a sea environment and was adsorbed firmly to the tested sediment. Lower amounts were bound under anaerobic conditions. The long-term leakage for all sediments was lower than 10 % of the total amount bound to the sediment.

The toxicities of water and sediment extract were also investigated on the harpacticoid copepod, Nitocra spinipes. The result showed that neither the water nor the extract of the sediment was acutely toxic to N. Spinipes.

FOI report " Methods for environmental risk assessment of defence-specific chemicals: 1. Explosives" FOI-R-0885-SE, maj 2003, ISSN 1650-1942 presents in brief, work performed in project during the period 1998-2001as well as the pilot research activities 1994 to 1997.

There has also been field research both in lakes and the sea with A. A. shells cleaved longitudinally to expose the explosive.

The University of Göteborg is studying the effect of experimental dumping of such an A. A. shell in marine sediment –water system *in situ*.

The pieces of the shell were placed in open boxes with sediment and the boxes were placed at the bottom so the TNT was exposed to the water or the mud. So far the fate and effects have been studied for 2.5 years. The results of this field research are that nothing seems to happen over a short periods, a couple of years. The leaching of TNT is so slow that it is not easily detected. There are the same amounts of TNT left in the shells and the only visible change was a change in colour from yellow to pink.

Sediment samples were also tested for toxicity with bioassays using Daphnia magna, Hyalella azteca and Nitocra spinipes. In some boxes, but not in all, the results suggested that the toxicity was increasing over time but no effects was detected in bioassays with the crustaceans. Therefore, no conclusion on increasing toxicity can be made at present.

The University of Göteborg has also done a laboratory assay of TNT fate and toxicity in seawater and sediment. The objective for this study was to determine its toxicity when added to a sediment water system at a laboratory scale. The result showed that TNT was dissolved passively from an object added to a sediment-water system and had some effected on Nitocra spinipes. This means that the most sensitive organisms in the bottom sediment can be affected negatively at a leaking dumping location. The University of Göteborg will also start a study the effect of TNT on fish.

The result of our research up to now is that dumped ammunition probably is not harmful to the environment and there is only a small risk for environmental contamination. The conclusion is that only small quantities of TNT will be released if TNT is exposed to water in the future. The diffusion will be very slow and the released TNT will be bound very hard to surrounding sediment.

This project will continue for at least 2 more years to elucidate long-term effects of dumped ammunition and to work out a control program so we can follow what happens in the future.

As I have said before most of the ammunition is buried in the bottom sediment.

In a few places however with a bottom of solid ground the ammunition will have an exposed situation and if the lake is shallow it is possible for civilian divers to reach the ammunition which can be very dangerous.

We have therefore tested different methods to salvage this ammunition if needed. Up to now we have salvage ammunition in two small lakes but this is both expensive and dangerous and we will not do it if it is not necessary. Our plan is to do nothing if the ammunition is not harmful for civilians.

To document the information from tests and research we keep a register of every location of dumped ammunition.

## SUMMARY

There are no good methods to locate ammunition buried in the bottom sediment in the sea.

Dumped ammunition is probably not harmful to the environment.

We will check the long-term effect with a control program every 5 to 10 years.

There is no reason from an environmental point of view to salvage dumped ammunition.