THIN-LAYER PLACEMENT PROJECT SHEET

Norway

September 2020

Location: Norway

Type: Sediment Remediation

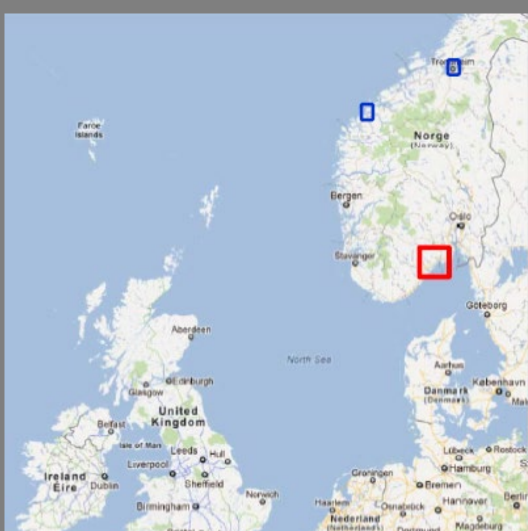
Area: 324,000 km^2

City: Oslo, Tromsø, Trondheim, Bergen

County: N/A

Main Agencies: Norwegian Geotechnical Institute, Norwegian Environment Agency, Norwegian Institute for Water Research

Country: Norway



Dioxin contaminated fjord near Oslo (in red box). Image adapted from Eek et al., 2012.

Background

The contamination of fjords and harbors in Norway can be attributed to years of pollution from industrial sources, urbanization, wastewater treatment, and traffic (Cornelissen et al., 2008, Breedveld et al., 2012). In harbors (including Harstad, Trondheim, Bergen, and Drammen) and fjords (including Grenlandfjords and Oslofjord), typical contaminants include organic and inorganic componuds such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), tributyltins (TBTs), and heavy metals (Jartun and Pettersen, 2010). The Norwegian Environment Agency has summarized the experiences from capping of contaminated sediments with clean soil in a report that was released in June 2016. Experiences from different capping projects in Norway over 25 years have been gathered. A difference between Norway and most other countries is that basically all capping of contaminated sediments in Norway has been done in marine sediments, basically in fjord and harbour areas. Isolation capping with an active layer (generally activated carbon), as well as thin layer capping (cap thickness less than 15 cm) have yielded a large amount of data that has been presented in published reports. The aim of this effort was to determine 1) what factors affect cap durability, 2) how the cap functions over time, 3) how different cap types function to mitigate contaminant leaching, and 4) how long does re-colonization of the biota take after cap placement.

Project Description

In Norway, the first capping project was performed in the Eitrheim Bay in Sørfjorden in 1992. Since that time, more than 20 capping projects have been performed. These efforts vary from a few thousand m^2 capped seabed, to approximately 1 km^2 (capping in Oslo harbour). In Kollevågen outside Bergen, municipal waste was reportedly placed in the shoreline and in the sea in the time period between 1930 and 1975. In 2005, the municipal waste was covered with a 0.5 m thick layer of rock material (up to 32 mm grain size), followed by a geotextile, and a 0.3 m thick erosion protection layer (up to 64 mm grain size). Monitoring investigations in 2012 and 2014 done by the Norwegian Geotechnical Institute (NGI) showed that the cap was damaged, and the waste that was below sea level was subsequently exposed at several locations. It was later determined that the most probable reason for the cap breach was the lack of stability with respect to erosion, slope stability and/or uneven settlements in the waste. In the Norwegian Environment Agency report, several capping examples are highlighted and discussed.

Findings

As a part of the Clean Oslofjord Project, several areas in Oslo harbor were capped at depths of 15-20 m with marine clay and sand. Several other areas in Oslo harbor were capped with crushed rock (grain size up to 8 mm). Investigations of the seabed 4 years after capping (NGI, 2015) showed that in an inner part of the harbor, where the ferries were docking, all capping material was gone and pure grey clay from the former seabed could be seen. This could be attributed to the strong current caused by the propellers of local ferries that had eroded away all the capping material. At a point about 50 m further out from the docking area, the cap was still there but contained a small amount of fines, indicating that the cap had been exposed to erosion but less than the docking area itself.

In another capping effort, a relatively fine-grained cap had been washed away from a smaller area where the seabed was exposed to a substantial propwash. Although in this case the exposed seabed was clean, areas adjacent to the cap were still intact. This example was highlighted in the report to show that a cap must be designed to withstand propwash in areas with ship traffic. It also shows that areas outside the cap perimeter are most subject to erosion (propwash), and should be applied to withstand erosion.

In a capping effort performed in 1992, the contaminated sediments in Eitrheim Bay were covered with a geotextile and capped with sand. Surveys done by divers in 1995 showed that the cap was intact and there was substantial biological activity on the surface of the cap. A new diver survey and sampling of sediments in 2001 showed that the surface of the cap had been recontaminated by land sources. An assessment done by DNV GL (2009) concluded that there were two probable main causes for the recontamination: accidental and regular discharges from local industries and waste disposals. An assessment of the regular discharges (those that were included in discharge permits) was done, which showed that regular discharges could cause substantial increase in the concentration of contaminants in the sediments (and the cap). One of the most investigated caps is the one that is covering the deepwater disposal at Malmøykalven in the Oslo fjord close to Oslo. The requirement in the permit was a 0.4 m cap layer. As a part of the follow-up, the capped area was investigated with respect to grain size distribution. The results showed that grain size distribution in the cap corresponded to the original cap material and thereby concluded that the cap was intact.

It has recently been shown that the presence of carbonaceous geosorbents (including black carbon, unburned coal, and kerogen) can cause strong sorption of PAHs in sediments. Cornelissen et al. (2006) studied sorption of native PAHs in four Norwegian harbor sediments of which high fractions (21−56%) of the total organic carbon (TOC) consisted of carbonaceous geosorbents as shown by organic petrography. PAH sorption coefficients were 1−2 orders of magnitude above predictions based on amorphous organic carbon partitioning alone. It was also indicated that an addition of 2% of AC by weight reduced the contaminant concentrations in water by factors of 21−153 for the four sediments (average values for all PAHs). It was shown that phenanthrene sorption to AC was, on average, reduced by a factor of 6 in sediment and AC mixtures compared to AC only.

The lessons learned from the reviewed capping projects are reported by Laugesen et al. (2017) as mainly positive. In most cases, several years after capping, the caps were still intact and functioning as intended. In a small number of projects, the caps were found to be locally eroded by bottom shear stress from ship propellers as when large ships are maneuvering close to quays in relatively shallow waters. Also, examples of poor soil conditions which led to damages in the cap due to slope failures or large settlements were also an important finding. Other issues highlighted in this assessment include the recontamination of the seabed after capping caused by supply of new contaminated material which was found in several cases. Such recontamination may be due to contamination from land, either from point sources or from diffuse sources such as runoff from contaminated land, landfills and/or from impervious surfaces via surface water. For this reason, sufficient control of pollution sources is important to reduce the likelihood of recontamination. It was also noted that recontamination may also be caused by spreading from adjacent seabed where no remediation of contaminated sediments has taken place. More information on the specific capping projects can be found at https://www.miljodirektoratet.no/globalassets/publikasjoner/M502/M502.pdf.

References

Breedveld, G., Cornellisen, G., Eek, E., Oen, A., Pettersen, A., Kibsgaard, A., Hauge, A. Cornelissen, G., Amstaetter, K., Hauge, A. 2012. Challenges in remediation of contaminated sediments in Norway. https://sednet.org/download/2%20Gijs%20Breedveld.pdf.

Cornelissen, G., Breedveld, G., Kalaitzidis, S., Christians, K., Kibsgaard, A., Oen, A. 2006. Strong Sorption of Native PAHs to Pyrogenic and Unburned Carbonaceous Geosorbents in Sediments. Environ. Sci. Technol. 40 (4):1197–1203.

Cornelissen, G., Pettersen, A., Nesse, E., Eek, E., Helland, A., Breedveld, G. 2008. The contribution of urban runoff to organic contaminant levels in harbor sediments near two Norwegiancities. Mar Pollut Bull. 56:565–573.

Det Norske Veritas (Norway) - Germanischer Lloyd (Germany). DNV GL. 2016. https://www.miljodirektoratet.no/globalassets/publikasjoner/M502/M502.pdf.

Eek, E., Oen, A., Breedveld, G., Schaanning, M., Beylich, B., Naes, K., Cornelissen, G. Field testing of thin layer capping with AC and passive materials in Norway. https://semspub.epa.gov/work/01/552472.pdf.

Jartun, M., Pettersen, A. 2012. Contaminants in urban runoff to Norwegian fjords. Journal of Soils and Sediments. 10(2):155-161.

Laugesen, J., Eek, E., Beckius, J., Hoygaard, E. 2017. Capping of contaminated seabed in Norway – lessons learned. https://sednet.org/wp-content/uploads/2017/07/2017-pres4-6-Jens-Laugesen.pdf.

Points of Contact

Gerard Cornelissen
Environmental Engineering - Norwegian Geotechnical Institute
gerard.cornelissen@ngi.no.

Main Agencies:

Funding for this project has been provided by:

Norwegian Research Council - Opticap Project # 182720
Swedish Research Council - Grant # 210-2007-282
Climate and Pollution Agency of Norway

Information on thin layer placement (TLP) case studies has been compiled as part of a DOTS/EWN project to provide a source of information, knowledge, and experience on TLP of sediment or dredged material in aquatic environments. The Thin Layer Placement Website and Map-Portal are funded by the US Army Engineer Research and Development Center (ERDC). POCs for the Thin Layer Placement Website and Map-Portal are:

- Damarys Acevedo-Acevedo, PE
  Damarys.Acevedo-Acevedo@usace.army.mil, 601-642-4375