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Dealing with microplastics pollution in sediments – technologies for prevention and remediation

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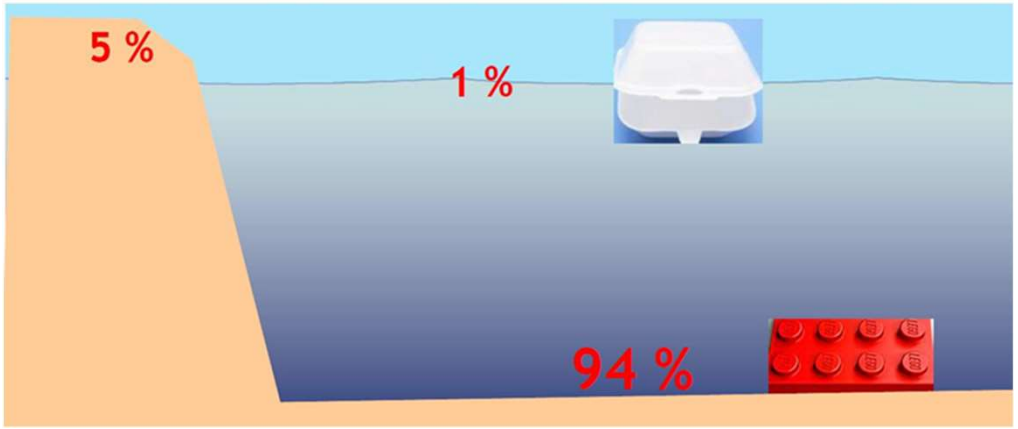
Microplastics in the ocean – a contamination problem

- Microplastics are found in almost every marine ecosystem of the world. They are highly persistent in the marine environment and are accumulating at increasing rates.
- Due to their small size (< 5 mm long), distinct shapes and diverse colours, microplastics are easily mistaken with food and ingested by several marine species, leading to adverse effects.
- Research shows that most of the plastic waste going to the sea ends up in the sediments (94 %) and only 1 % is floating. The remaining 5 % of the plastic waste ends up on the shores.



Subjects in the project

A project initiated by the Nordic Council of Ministers has studied how microplastics/plastics can be prevented from entering the sea or how sediments already contaminated with microplastics/plastics can be remediated.

The project included the following subjects:

- Overview of plastics/microplastics from tunnelling and other blasting activities that can enter the sea.
- Estimates of the amount of plastics that can enter the sea from shotcrete and tunnelling/blasting activities in the Nordic countries.
- Measures to prevent microplastics/plastics from blasted rock/shotcrete from entering the sea and the sediments.

Overview of plastics from tunnelling and other blasting activities

During tunnel construction plastics are used in explosives, lead wires (including shock tubes) and detonators as well as fibrous reinforcement (including macrofibres and microfibres) of shotcrete linings in tunnels.

Dynamite with plastic cartridge

A shock tube detonator with a blasting cap

Application of shotcrete

Electronic wireless detonator

A blasting wire with a blasting cap

Macrofibres - mainly used as reinforcement in shotcrete

Microfibres - mainly used as fire protection in shotcrete

Estimates of the amount of plastics that can enter the sea from shotcrete – Example Norway

- 60 km of tunnels are built every year in Norway that are treated with shotcrete
- Typical area of the ceiling and walls of a road tunnel covered with shotcrete: 30 m^2/m tunnel
- Average thickness of the shotcrete that is placed: 4 cm
- Amount of plastic fibres in the shotcrete: 6 kg fibres/m^3 shotcrete
- Assuming there is 10% spill of shotcrete with plastic fibres

There is a yearly potential for 43,000 kg spill of plastic fibres from shotcrete in new-built tunnels that could go to the sea.

Estimates of the amount of plastics that can enter the sea from tunnel blasting – Example Norway

- 60 km of tunnels are built every year in Norway with blasting technique
- A typical tunnel cross section is 75 m^2
- For every blast typically 150 holes with a length of 5 m are drilled
- This generates approximately 7 million m^3 of blasted loose rock per year
- Shock tubes with detonators (Nonel) are mostly used for tunnelling in Norway. They contain 5 grams of plastic per metre. It is assumed that the plastic does not get destroyed from the blast

There is a yearly potential for 70,000 kg spill of plastics from blasting new tunnels that could go to the sea. This is based on the assumption that shock tubes are used.

Measures to prevent microplastics/plastics from blasted rock/shotcrete from entering the sea and the sediments

The obvious ways to prevent microplastics/plastics from ending up in the sea and the sediments is that we use less plastics and that we recycle the plastics. The measures can be divided into:

- Avoidance – it is possible to minimise or eliminate plastic by investigating options to avoid or minimise blasting at an early stage of the project
- Substitution – it is possible to substitute plastic fully or partially with other materials
- Impact reduction – it is possible to reduce the impact of plastics by controlling the plastic and avoiding the plastic from spreading

The suggested measures should contribute to an estimated minimum of 75% reduction of microplastics/plastics emissions from blasted rock and shotcrete to the sea.

Avoidance

- With the exclusive use of a TBM, all plastics that would have been generated from blasting and shotcrete can be avoided.
- If blasting is chosen, the use of plastic should be minimised. When the plastic once has entered into the blasting or shotcrete operation it is very difficult to separate the plastic afterwards.
- Careful planning is vital to avoid plastics pollution from tunnelling (blasting and shotcrete activities).
  - The planning should also consider taking into account what cleaning up of microplastics/plastics that is spread to the sea will cost and the negative reputation of the project plastics pollution would give.
- It has to be underlined that safety can of course never be compromised and always has to have the highest priority.
- Training and education of the blasting team will help to motivate the team and get a better understanding of the importance to avoid plastics pollution.

Substitution

With substitution is meant that the plastic is fully or partially replaced with other (preferably) more environmentally friendly materials.

- Suggestion 1: Instead of detonators with firing cables that are currently mostly used, electronic wireless detonators can be used. Electronic wireless detonators have no lead wires (the amount of plastic will be reduced drastically), but are more expensive.

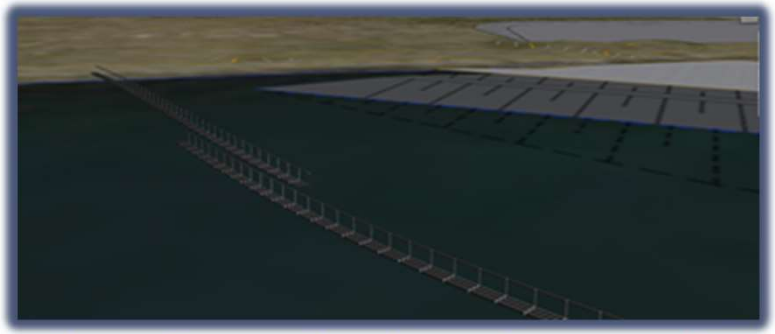
- Suggestion 2: Blasthole casings made from paperboard can be used instead of plastic casings.

- Suggestion 3: Reduce the amount of plastics used. For example, reduce the amount and length of the detonators and the size of plastic connectors.
- Suggestion 4: Substitute the plastic macrofibres in shotcrete with steel fibres.

Impact reduction

Impact reduction of plastics will help to control the plastic and avoid the plastic from spreading.

- Suggestion 1: Utilisation of blasted rock in constructions on land, or if not possible, local landfilling. This will drastically reduce the possibility for plastics to spread to the sea.
- Suggestion 2: Use of temporary flexible barriers based on booms and nets. Such constructions need frequent collection of floating plastics and maintenance of the barriers and nets.



- Suggestion 3: Construction of an embankment surrounding the disposal area prior to filling blasted rock containing plastics.
- Suggestion 4: Use (sinking) plastics with a density greater than water and plan for sediment capping in the case of using blasted rock for offshore construction or deep- water landfills.

Acknowledgments

- Thanks to the Nordic Council of Ministers who sponsored this project.
- The whole report can be found here: https://pub.norden.org/temanord2020-520/
- All pictures and illustrations in the presentation are from the report, where the detailed origin of each picture/illustration can be found.

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