MARINE AND WATER DISASTERS - CASE STUDY

STUDY 5/A – NORMAL SYSTEM

1. Starting position

In the case of oil pollution of port sediment, a **chronic re-contamination phenomenon often** develops, during which the oil bound in the sediment resurfaces from time to time. This is particularly true **in old, historically polluted ports**, industrial docks and coastal logistics areas.



The situation is aggravated by the following factors:

- The presence of thick layers of sediment, up to a meter long, in which oil is trapped and accumulates over a long period of time;
- Periodic tides, intense ship traffic and storms that cause re-pollution by regularly stirring up sediment;
- proximity to coastal infrastructure (quays, canals, industrial facilities), which increases the risk of secondary spread and corrosion damage;
- Increased environmental sensitivity, especially the impact on aquatic life and tourist areas, which can cause economic and social damage in the long term.

The primary goal of the intervention is **to eliminate chronic re-pollution**, stabilize sediment and ensure long-term ecological restoration, in accordance with the provisions of the **EU Water Framework Directive** and the **HELCOM recommendations**. Examples include the docking areas of historic industrial ports, such as **Baltimore or Rotterdam**, where pollution from decades ago is still a recurring problem today, costing up to **millions of euros a year**.

2. Nature of pollution (normal system)

- The presence of oil-contaminated sediment on the harbour bottom, where hydrocarbons bind to organic matter and sediments;
- Periodic upwash by tides or sedimentary turmoil with repetitive surface oil film formation (typical propagation rate: 0,2 to 0,5 m/s);
- Infiltration into coastal soil and water column, causing chronic toxicity
- Secondary pollution due to mechanical disturbance of sediment, which further increases biodiversity damage.

Contamination is typically **heavy oil or bunker oil residue** that is highly hydrophobic but partially dissolves and mobilises over time, causing long-term ecotoxic effects (e.g. 20-40% mortality of mussel stocks in affected areas).

3. Traditional intervention methods

3.1 Localization

- Use of physical barriers (e.g. silicate curtains, temporary barriers) to reduce sediment turmoil;
- Monitoring systems (probes, sonars) for detecting back-contamination.

Limitations:

- Barriers do not completely prevent buoyancy (efficiency 40-60%);
- Ship traffic and tides regularly break through localization;
- Long installation and maintenance times, up to months, increasing costs by 20-30%.

3.2 Surface removal

- Mechanical raking or dredging to remove sediment;
- Spraying absorbent materials onto the returning surface film.

Absorbents used:
Perlite, zeolite, vermiculite, PP-based synthetic materials.

Limitations:

- Absorbents become saturated with water, their effectiveness decreases by 30-50%;
- Raking increases sediment mix-up, increasing recontamination by up to 50%;
- Large amounts of contaminated sediment are generated as waste (up to 10 times the volume) with high treatment costs.

3.3 Surface and structure treatment

- Washing or bioremediation after dredging;
- Sediment exchange with clean sediments.

Limitations:

- Washing spreads the oil, increasing chronic pollution;
- Bioremediation is limited in slow, oxygen-poor sediments;
- The cost of dredging and disposal is extremely high (up to 60% of the total cost).

4. Operational challenges

- Long-term monitoring need due to chronic nature;
- Coordination of several actors (port operators, authorities, local communities);
- Limited access with boat traffic;
- Rapid return of re-contamination with annual maintenance costs of millions of euros.

5. Result - normal system

- Re-contamination can only be partially eliminated (50-70%);
- Chronic upsurge persists;
- Continuous post-cleaning and monitoring is required;
- Significant long-term ecological damage (biodiversity loss of 30-50%).

STUDY 5/B - EXOLINE® OIL STOP

1. Starting position

The baseline is the same as described in Study 5/A. The **purpose of using** Exoline® Oil Stop **is not to replace traditional interventions**, but **to improve their material and functional properties**, especially in the case of chronic sediment contamination.
The main objectives of the intervention are:

- Elimination of chronic back-contamination by sediment stabilization;
- Ensuring long-term oil retention in sediment;
- Protection of coastal ecosystems.

The **excellent** hydrophobic bonding **and high** thermal stability **of Exoline® Oil Stop** (up to 370°C alone, ignition 700-800°C) allow for long-term stabilization.

2. Nature of pollution with Exoline®

- **Exoline®'s** highly water-repellent, positively charged powder with a particle size of > 4 microns creates a selective bond with the oil phase;
- The rate of float can be reduced by 70-90%;
- A stable trapping zone is formed in the sediment, minimizing periodic re-contamination.

3. Improved intervention methods

3.1 Localization with Exoline®

- Application of physical barriers **with sediment layers enhanced with Exoline® (e.g. perlite or zeolite + 20% Exoline®);**
- Monitoring systems reinforced with hydrophobic zones.

Result:

- Oil in the sediment is immobilized (up to 10× mass fixation, 26 m^2/g specific surface area);
- The chance of swimming up is reduced by up to 80%;
- Long-term retention up to 95%.

3.2 Surface removal - absorber enhancement

- **Exoline®** protects absorbents from water saturation;
- Recoil is reduced;
- Fewer absorbents are required.

Result:

- Waste is reduced by ~50%;
- More stable treatment in sediment;
- Back-contamination can be reduced by up to 85%.

3.3 Surface and structure treatment

- **Mixing an Exoline®** into the sediment as a trapping layer;
- Layered stabilization instead of raking.

Result:

- There is no increase in toxicity;
- Chronic upspawn practically disappears;
- Oil retention of up to 95%.

4. Operational impact

- Reaction time is reduced by 50%;
- Fewer repetitive interventions;
- Simplified logistics;
- Maintenance costs are reduced by up to 60%.

5. Result - improved system

- Permanent re-contamination elimination (≈95%);
- Faster recovery (months instead of years);
- Significantly lower waste and post-cleaning costs;
- The long-term ecological risk can be reduced to 10-20%.

Final Note

The study presents a subsequent technological comparison. Exoline® **Oil Stop** has not been used in the cases referred to; the aim is **to demonstrate the material improvement potential of existing systems** in the case of chronic sediment contamination in ports. It is recommended to launch pilot projects in a real port environment, supported by quantitative data (cost-benefit, environmental impact, long-term monitoring), in accordance with **the EU Water Framework Directive** and **HELCOM recommendations**.