Sediments: a source of chemicals for the marine environment, in more than one way

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Introduction: The implementation of the Water Framework Directive (WFD) is now at a stage where the necessary measures are being prepared to achieve the required improvements of the water quality. A study has been conducted for selected chemicals, supported by mathematical modelling, aiming at establishing the effectiveness of the planned emission reduction measures to achieve the relevant water quality targets in the Dutch coastal waters in 2015 and 2027. During this study, the role of sediment as a source of chemicals for the marine environment needed to be elaborated quantitatively. In the first place, the chemical fluxes related to dredging spoil distributed in the Dutch coastal waters had to be quantified. Secondly, the role of marine and estuarine sediments as a source of chemicals in a situation where the emissions show a strong temporal trend needed to be quantitatively explored.

Methods: The study consisted of different parts: (i) data collection, (ii) model set-up and validation, and (iii) diagnosis and prognosis, supported by mathematical modelling.
Key data sets proved to be the emission database for the national waters (Emissieregistratie), as well as the marine sediment sampling data collected via the national water quality monitoring programme. The model set-up relied on existing hydrodynamics and fine particles transport models for the southern North Sea. Due to the representation of seasonal sediment buffering in the latter, the present model for chemicals is able to take into account the accumulation and release of chemicals from the marine sediments. An additional feature was the compilation of a comprehensive sediment and chemicals budget for the Rotterdam Harbour area.

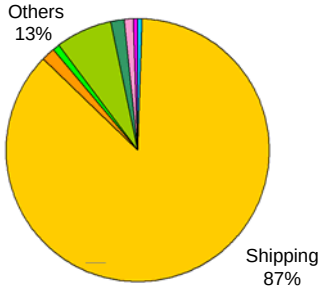

Fig. 1: Sources of TBT in the 12 mile zone (2005).

Results: After a successful validation, the model was used to diagnose the 2005 situation and provide a prognosis up to 2027, for cadmium, copper, zinc, tributyltin and five polycyclic aromatic hydrocarbons (PAHs). Fig. 1 illustrates the 2005 average source apportionment of the concentrations of tributyltin (TBT, an agent in anti-fouling coatings which is now banned) in the Dutch 12 mile zone.
Fig. 2 shows the prognosis of total TBT concentrations for 2015 in the water column, with and without taking into account the role of marine sediments as a buffer of chemicals, which results in a release of TBT following the recent ban on TBT-based anti-fouling coatings.

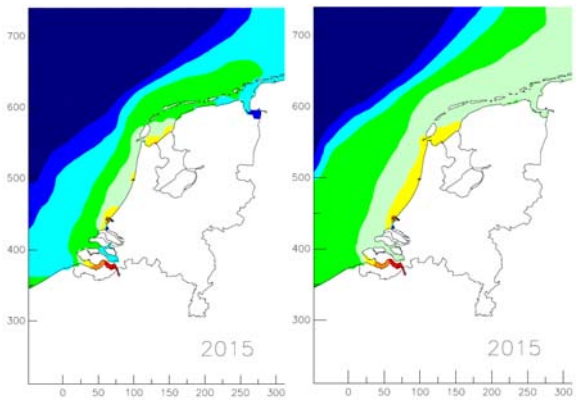

Fig. 2: Prognosis of TBT concentrations in 2015, without (left) and with (right) effect of sediment accumulation. Orange and red colours indicate concentrations exceeding the WFD standard.

Discussion: The diagnosis revealed the sources of all nine analysed chemicals in the Dutch coastal waters. The example for TBT presented above clearly shows the dominant position of ships emissions. The role of distributed dredge spoil turned out to be much smaller than expected.
The prognosis resulted in a state-of-the-art insight in the expected effectiveness of planned emission reduction measures for the nine analysed chemicals. For TBT, the measures are expected to be effective to achieve the WFD targets by 2015, even if the role of buffering marine sediments is taken into account.