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Studies of UV techniques for treatment of the aqueous phase from dredging operations of tributyltin contaminated sediment

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Abstract

The extensive use of organotin pesticides as anti-fouling agent in ship paints has led to a massive pollution of the sediment and to a lesser extent the water of industrial harbours worldwide. From the beginning of the 1960's and up until it was banned in 2003 by the International Marine Organization (IMO), tributyltin (TBT) was considered the most effective active ingredient in anti-fouling paints. The prevention of biological settlement on ship hulls decreases fuel consumption, biological corrosion rates, and frequency of dry-docking, and in 2004, it was estimated that TBT-self-polishing copolymer paints covered more than 70-80% of the world's fleet. However, the cost of the success is paid by the coastal marine environment and in particular the marine species inhabiting sediment and water of ports, harbours and shipyards, where high concentrations of TBT exceeding acute and toxic levels is found.

The concentration of TBT in sea water is typically very low (on the level of nanogram per liter), but due to its strong accumulation in sediment it constitutes a challenge of concern, when sediment is dredged from ports, harbours and channels to maintain sail routes, extent dock areas etc. During sediment dredging and subsequent disposal at upland sites, sea water is used as a carrier medium, and discharge of the drained water and run off to the marine recipient is authoritatively regulated. Large shallow areas for sediment disposal with good sunlight penetration are needed for the natural TBT degradation to be sufficient to maintain discharge limits. In order to save valuable land in areas of typically high industrial activity, artificial treatment of the water drained from the upland sites can be economically beneficially.

This study presents results from photolytic and photocatalytic treatment experiments conducted in cooperation with the Port of Esbjerg where the influence of the sea water matrix, different types of high and low pressure ultraviolet (UV) lamps and different reactor design have been examined. The investigation showed that the photolytic rate of degradation in sea water was reduced by 41% compared to the degradation in dist. water. Moreover, the photocatalytic TiO_2 surface was inactivated by the relatively high salinity of the water. With the same type of lamp, the rate of removal was dependent only on the specific amount of UV energy supplied to the water regardless of the specific power used. The high energy medium pressure Hg lamp (L1) was found to be the most efficient compared to the four low pressure lamps used, and the energy consumptions were estimated to be in the 7-8 Wh L^{-1} range per log reduction. This study has demonstrated a feasible method for abatement of TBT in this specific sea water matrix.

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