MARINE ECOSYSTEM MODELS AND THEIR APPLICATION IN WASTE WATER AND COASTAL ZONE MANAGEMENT

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Introduction

In the coastal zone conflicts between interests of the various contributors to the pollution load, eg nutrient load, often occur. The pollution load from points sources eg waste water treatment plants is easy to measure/estimate and easy to regulate from a management point of view. The non-point pollution load that arrives at the coast via rivers is much more difficult to determine and it varies during the year and from year to year as a result of weather conditions. It is equally difficult to regulate and reduce due to its origin – run-off from farmland, forests etc. The non-point pollution can however in many cases be the dominant contributor to nutrient loads. Discussions arise at consent setting for the direct point sources whether the costs of refining the treatment process were better spend on mitigation of the run-off from land by eg changes in farming practises, enhanced nutrient retention in wetland areas etc.

Revision of consents for waste water treatment plants and industries along the Swedish coast of Øresund (the sound between Denmark and Sweden) takes place presently. According to the law and rules in Sweden, three aspects related to this need to be taken into account in this process: the technical possibilities, the economical consequences and the environmental significance. The latter means that consideration should be given to the solution beneficial from an environmental point of view. On the other hand, demands to the efficiency of the treatment plants can not be defended if no documentation of an environmental improvement can be demonstrated.

All discharges of nutrients contribute to the environmental state in Øresund. This includes the waste water discharges, industrial and riverine inputs from the Swedish side as well as the contributions along the Danish coast. All loads must be taken into account in evaluations of changes in specific discharges. A mathematical model of the water quality and biological conditions in Øresund was used to analyse the effects of changes in nutrient load.

The discharges from the wastewater treatment plants at the Swedish side were analysed by testing a limited number of the most likely demands from the authorities. The contribution from the rivers was determined by assuming a certain reduction compared with a reference year, which in Swedish planning is 1985. The reductions were estimated assuming various mitigate actions in relation to agricultural leakage, wetland engineering, retention ponds for the nutrients particularly nitrogen, etc.

Methods

The effects of changes in the nutrient discharge from treatment works and rivers along the Swedish coast of Øresund were investigated using the hydraulic and ecological modelling system MIKE21 (Warren & Bach, 1992). This fully dynamic, finite difference model being two-dimensional horizontally was set-up using a 500x500-m grid. The model area covered the stretch from Skanör (in the south) to Kullen (in the north). The following local counties were included: Höganäs, Helsingborg, Kävlinge, Lomma, Landskrona and Malmö.

A full annual cycle was modelled from autumn 1992 to autumn 1993, which made it possible to evaluate the effects in winter as well as during summer.

The environmental elements investigated were: nutrient spreading, eutrophication, effects on benthic vegetation (eelgrass and filamentous algae). A eutrophication model was used for this purpose describing a number of organisms: Phytoplankton, filtrators (e.g. zooplankton and common mussel), filamentous algae and eelgrass and their sensitivity to nutrient availability and as such also to nutrient discharges.

The eelgrass meadows in Øresund are the basis for fish breeding, increase the biodiversity in and stabilise the sediment. Improvement in growth and biomass of eelgrass is therefore a positive effect. Increase in phytoplankton and macro-algae biomass on the other hand leads to e.g. higher water turbidity, oxygen consumption at the sea bottom and nuisance at the coast including beaches and should therefore be avoided.

The eutrophication model used was originally established, calibrated and validated as part of the investigations of the potential impacts of the Øresund link between Denmark and Sweden /2/. It has been extended geographically to the north in this study.

In total six different combinations of discharges from waste water treatment plants and riverine inputs were tested. Three different sets of nitrogen and phosphorus concentrations in the waste water and two values for reduction in the riverine inputs (50% and 30% compared with the reference year 1985) were combined. The table below shows the nitrogen and phosphorus load to Øresund (from Sweden and Denmark) for the six scenarios, the reference year and the present conditions (represented by the 1994 numbers) and separated into three types of contribution: waste water treatment works, rivers and industry.

N-inputs (tonnes/year):	1985	1994	Sce. 3	Sce. 4	Sce. 5	Sce. 6	Sce. 7	Sce. 8
Rivers	7439	7739	5180	5180	5180	3970	3970	3970
Waste water treatment plants	7371	4856	1828	2009	2188	1828	2009	2188
Industry	145	271	118	118	118	118	118	118
Total	14955	12890	7126	7307	7486	5916	6097	6276
P-inputs (tonnes/year):	**1985**	**1994**	**Sce. 3**	**Sce. 4**	**Sce. 5**	**Sce. 6**	**Sce. 7**	**Sce. 8**
Rivers	262	185	149	149	149	119	119	119
Waste water treatment plants	1479	772	235	253	298	235	253	298
Industry	424	8	10	10	10	10	10	10
Total	2165	965	394	412	457	364	382	426

The difference between on the one hand the scenarios 3, 4 and 5 and on the other hand the scenarios 6, 7 and 8 is the assumed reduction in riverine inputs (30% for scenarios 3, 4 and 5 and 50% for scenarios 6, 7 and 8). The differences between 3, 4 and 5 are the nitrogen and phosphorus concentrations in the waste water and similarly the differences between 6, 7 and 8.

Results

The results of the model calculations showed a major improvement in the water quality comparing the 1985 conditions with the plans represented by e.g. sce. 3. A 5-20 % reduction in the phytoplankton production and biomass and an eelgrass biomass increase up to 25 % were predicted.

Comparison of the results for the various scenarios showed that no significant difference could be found of varying the nutrient concentrations in the waste water (comparing scenarios 3, 4 and 5 individually or comparing scenarios 6, 7 and 8). Only very locally at the major waste water discharges could differences be detected in the modelling results. It is however important whether the reduction in riverine input is 30 % or 50 % (e.g. sce. 5 compared with sce. 8). A 50 % reduction in riverine input compared with 30 % shows a significant improvement of the ecological conditions according to the model calculations. A 10 % decrease in phytoplankton biomass and about 10 % increase in eelgrass biomass along the coast was predicted.

The simulations showed that it is very important to include all nutrient loads when the effects of changes for some of the contributors should be evaluated. It also demonstrated that the non-point pollution (agricultural run-off and nutrients transported by rivers) can be very important compared with the point sources at a coast line.