Sustainable usage of coastal ecosystems: model determination of the upper limit of organic loading on coastal ecosystems

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In a coastal ecosystem, organic matter is decomposed partly in the water column and mainly in the bottom layer. Overloading of organic matter that unbalances the rate of oxygen supply on the bottom induces the depletion of dissolved oxygen in the bottom layer, which leads to the breakup of sustainable material cycle between the surface and bottom layers. The decomposition of organic matter is composed of two different processes, i.e. aerobic and anaerobic decomposition, which change from the former to the latter with the decrease of dissolved oxygen. Because the rate of aerobic decomposition at the bottom is zero both under conditions of no and excessive organic loading, there must be at least one peak of the oxygenic decomposition at an intermediate rate of organic loading, which defines the upper limit of the assimilative capacity of an ecosystem.

We have already presented the one-dimensional model of coastal ecosystems, which can predict the upper limit of organic loading (Omori et al., 1994). In the present paper, we will give a more practical model, which can predict the upper limit only by using the exchange rate of water mass between organic loading area and its neighboring waters. The practical model is given as follows:

$$hxdD/dt=Exhx(D0-D)-Axkdx(D-Db)/Dz,$$
$$hbxdDb/dt=-k1xMxDb-k2xSxDb+kdx(D-Db)/Dz,$$
$$hbxdM/dt=Qp-k1xhbxMxDb-k3xhbxM/(Db+k4),$$
$$hbxdS/dt=k3xhbxM/(Db+k4)-k2xhbxSxDb.$$

where k1-4, and kd are constants and Dz is the depth of the bottom boundary layer. All other variables are explained in the caption of Figure 1. From the above equations,
we can get the following sustainable upper limit of organic loading:

$$Qp,max=D0/(A/E/h+Dz/kd).$$

Then, the optimum loading rate of organic matter, Qp, opt, that can be sustainable and keep

the best condition of a coastal ecosystem whose oxygenic decomposition rate is the maximum will be between zero and the upper limit.

$$0 < Qp, opt < Qp, max.$$