THREE-DIMENSIONAL MODEL FOR THE SIMULATION OF SUSPENDED MATTER PELAGIC-BENTHIC EXCHANGES IN COASTAL WATERS

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Abstract

A three-dimensional model has been formulated for the description of fine matter exchanges between sea-column and benthos in the coastal environment. The physical processes affecting the properties and the propagation of a sedimentary plume, embodied in the model, include coagulation-deflocculation, the effects of stratification and ambient density to the vertical propagation and the density of the sedimentary plume, settling and deposition on the seabed, self-weight consolidation of deposited particles and erosion of the bed. The usability of benthic ascidia as biological filters was investigated by the exploitation of *in situ* and laboratory experiments.

Keywords : Aegean Sea, Coastal Models, Coastal Processes.

Introduction

The mathematical model [1] is based on the tracer method and thus describes the sediments entering the marine environment as particles each representing particular mass of matter. Every particle bears personal information in the form of indicators that express the total of the mass that composes the particle, which may however differ between the various particles included in the simulation, enabling the tracing of changes in the characteristic properties of the sediments with time. The physical processes affecting the properties and the propagation of the sedimentary plume embodied in the model include flocculation, settling, deposition, consolidation, resuspension and erosion of the bed.

Description of the mathematical model

The movement of each particle under the influence of coastal currents is analyzed into a deterministic part that expresses advection, controlled by the local fluid velocity and the settling rate of the particles and a stochastic that accounts for the random Brownian motion of the particles. Changes of the characteristic diameter of the cohesive aggregates due to coagulation and deflocculation processes are defined applying the simplified flocculation model. The effect of ambient density to the density of the particle is calculated in relation to the porosity of the cohesive aggregate and the density of the primary particle. These properties are used for the determination of the settling velocity of each particle applying Stoke's law for cohesive sediments. When a particle reaches the bed the shear stress conditions determine the possibility of the particle to deposit and the beginning of self-weight consolidation during which the critical stress for resuspension of the material increases with time the particle remains in deposition. After the completion of the process the particle is considered to be part of the seabed.

The sources of sedimentary particles that can be included are various, among which rivers, aeolian transported matter and erosion of the seabed. Input parameters of the model are hydrodynamic and physical parameters data that include values of seawater velocities, salinity and temperature.

Application of the model for the simulation of the efficacy of benthic ascidia as biological filters

The model has been applied for the investigation of the applicability of benthic ascidia as biological filters. Specifically the model described has been properly adapted so as to mathematically express the filtration of marine water by the ascidia and the removal of suspended material from the water column.

For this purpose the findings of a research program carried out in the gulf of Thermaikos (NW Aegean) for the potential of the ascidia *Styela Plicata* [2] were put to use. Dense ascidia populations were found in the SW gulf, which is the area of application for both the *in situ* [2] and the mathematical experiments. The average filtration efficacy of the ascidia e_{filt} was determined experimentally to be 40%, whereas the length of the ascidia from *in situ* measurements was of an average of 6cm. These parameters were put to use as loss-terms of particle mass in conditions a particle approaches the ascidia populations in their detection distance (d_{det}) [3]. Namely the possibility of absorption P_{ab} of a particle in suspension at a distance z_b from the bed is considered to be zero if $z_b<d_{det}$ and 1 otherwise. The time considered for the assimilation of the particulate matter by the ascidia (t_{ass}) was found to be 2hrs, period during which the absorbed particle is excluded from the calculations. Following full assimilation ($t>t_{ass}$) the particle reenters the flow with reduced mass (m_p):

$m_p= (1-e_{filt})\, m_{in}$

where m_{in} is the initial particle mass.

The results from the mathematical experiments conducted in the area fully support the findings of the laboratory experiments performed regarding the applicability of benthic ascidia as biological filters, since the efficacy in removing suspended matter from the water-column has reached satisfying percentages.

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References

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