# ONE DIMENSIONAL SEDIMENT TRANSPORT MODELLING IN ESTUARINE FLOWS. *ANEROGEN.*


## SUMMARY

Sediment transport in rivers is one of the main concerns in river engineering. To project infrastructures or navigation in rivers, civil engineer needs to predict the evolution of the river. For instance, deposition of suspended sediment in an estuary causes a restriction of navigation and can exacerbate flooding problems. Moreover, changes in the water level produced by erosion or deposition, and high-suspended sediment concentration causes environmental problems that the civil engineer must minimize. Sediment transport is a complex problem, which does not have a consistent theoretical basis. The different empirical studies from one author to another can differ in a 100%. The best method to solve these problems, after the spectacular evolution of computational systems, are numerical models, showing some advantages compare to the physical models traditionally used. However, one-dimensional simulation of sediment transport is not sufficiently mature. Many key factors still need in-depth study and investigation.
The objective of this paper is to develop a new one-dimensional complete sediment transport model in estuaries (ANEROGEN). The model should solve the equations of Saint Venant, a complete sediment continuity equation and an advective-diffusion equation for the suspended sediment. The Saint Venant equations, resulting of the basic principles of conservation of mass, momentum and energy have been reviewed to allow change in the flow direction. Particularly the advective terms of the momentum equation have been rewritten.

The sediment transport can be divided in bed-load and suspended load. In the bed-load modelling the empirical study of Meyer-Peter and Muller has been used to calculate the transport rate, whereas in the suspended load an equation of advective-diffusion transport has been applied to reflect no equilibrium situation, using the Van Rijn relationships to calculate the net erosion or deposition term. Then the sediment continuity equation is derived from the Exner equation for bed-load transport including the net re-suspension.

The Finite Volume method has been applied yielding an implicit model. Central differencing has been applied to the Saint Venant and Exner equations whereas the ULTIMATE QUICKEST scheme has been adapted in the advective-diffusion equation for suspended transport. The QUICKEST scheme is based on quadratic upstream interpolation. It is an interpolation in space and in time, so it was design to be used in an explicit method. The ULTIMATE QUICKEST scheme applied is more accurate and reduces the oscillations in problems with high gradients of concentration. Applied to an implicit scheme these features remain. The user supplies the boundary conditions and the continuity equation is applied in the semi-volume control to solve the missing variables. The system equation is solved in two steps. In the first the Saint Venant equations and the Exner equation for bed-load is solved. In a second one the advective- diffusion equation of suspended sediment is solved, updating the bed elevation changes with the complete sediment continuity equation. The resolution of the non-linear systems has been solved using a Newton-Raphson method. It has been necessary to calculate analytically the Jacobian matrix, stored as a banded matrix, to improve the performance. The program allowsany kind of cross-sections and bed profile being transformed in a function stored as a spline. It has been programmed in FORTRAN language as a dynamic library. This feature allows calling the

routines from another program, maybe programmed in another language. Then, an easy-to-use interface has been developed using Visual Basic. The Excel capabilities have been used to the input-output exchange and storage, using the OLE component model of Excel. The user can analyse easily the results using Excel features and options.

The model has been contrasted with analytical solutions for a simple hydrodynamic problem and with a simple advective suspended sediment transport problem. It has been also tested with experimental data obtained in laboratory experiments for the bed-load problems. Finally the hydrodynamic model and the suspended load has been tested with real data of the Humber Estuary (England).