

Numerical modelling of wave interaction with coastal and offshore structures using a CFD solver

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Sustainable development of coastal and offshore structures – from conceptual layouts, optimisation, stability and environmental assessment to detailed design – requires a thorough understanding of coastal and offshore processes. Numerical modelling is a suitable tool to investigate these physical processes and to deliver valid, accurate, efficient and usable results and solutions. Parallel to the increase of the available computational power, the use of numerical models is growing rapidly, also in the design of all kinds of coastal and offshore structures, such as breakwaters, wave energy converters, etc.

In this work, the Computational Fluid Dynamics (CFD) software OpenFOAM (<http://openfoam.org/>) has been used to study wave interaction with coastal and offshore structures. The numerical simulations are performed in a numerical wave tank, which is the equivalent of a physical wave tank used for experimental model testing at a smaller scale. However, the idea behind both wave tanks is the same: reproducing the physics as observed in the ocean or the sea in a controllable environment to study particular physical processes in detail. The numerical wave tank is characterised by a length, width and height. Boundary conditions are needed at the sides of the tank, for example to generate and absorb waves. The CFD software solves a set of partial differential equations, the Navier-Stokes equations, representing the physics with a very high accuracy. Therefore, the numerical wave tank is split up in a large amount of small grid cells and the governing differential equations are discretised to algebraic equations using a finite volume method. In each grid cell, the algebraic equations are solved numerically using linear systems, taking the boundary conditions into account.

In this study, we present several simulations of coastal and offshore structures using a CFD solver:

- Wave propagation in a two-dimensional wave flume,
- Wave breaking on a sloping beach,
- Wave run-up on a monopile,
- Modelling of wave energy converter arrays.

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Keywords: waves; numerical modelling; CFD; OpenFOAM; numerical wave tank

BOOK OF ABSTRACTS



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PREFACE

This is the 'Book of Abstracts' of the 17th edition of the VLIZ Marine Science Day, a one day event that was organised on 3 March, 2017 in VIVES, Brugge.

This annual event has become more and more successful over the years. With more than 400 participants and more than 100 scientific contributions, it is fair to say that it is the place to be for Flemish marine researchers and for the end-users of their research. It is an important networking opportunity, where scientists can meet and interact with their peers, learn from each other, build their personal professional network and establish links for collaborative and interdisciplinary research.

Marine scientists from all Flemish universities and scientific institutes – and representing all marine science disciplines – have contributed to this volume. The book thus illustrates the diversity, quality and relevance of the marine sciences in Flanders (and Belgium): it provides a beautiful and comprehensive snapshot of the state-of-the-art of marine scientific research in Flanders.

Pre-doc and post-doc scientists present their research in an exciting way and communicate their fascinating science – and its importance to society – to the wider public. We thus hope to demonstrate the excellence of Flemish marine science and to increase its national and international visibility.

The volume of research that is presented here holds a great promise for the future. It shows that marine science is a very lively discipline in Flanders, and that a new generation stands ready to address the grand challenges and opportunities that our seas and oceans represent.

New this year are the Brilliant Marine Research Ideas, an initiative sponsored through the philanthropy scheme of VLIZ. We are proud to announce that an initial batch of 4 ideas will be sponsored. We'll hear about the results in the next edition of the Marine Science Day.

I want to congratulate all participants with their contributions, and I invite them all to become members of VLIZ and to actively participate in our events and activities in the future.

Bruges, 3 March 2017
Prof. Dr Jan Mees
General Director VLIZ

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**ORAL, DEMO AND
POSTER PRESENTATIONS**

Development of diffusive gradients in thin films (DGT) passive samplers for simultaneous measurement of Platinum, Palladium, Rhodium and Mercury in surface water

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Increasing anthropogenic activity often has detrimental effects on human health and the environment due to the accompanying emissions of toxic compounds. The increased application of Platinum Group Elements (PGEs) (Pt, Pd, Rh, Ru, Os and Ir) in the last decades, especially as car catalysts but also in other applications, makes it necessary to monitor the concentration of these elements in the environment, investigate their environmental transformations and bioavailability. Mercury (Hg) is also recognized as one of the most toxic trace elements, whose natural cycle has been altered by anthropogenic activities. Complex biogeochemical transformations result in different chemical species, with varying toxicities and mobility, which need close monitoring. The concentration of these elements usually extremely low in the aquatic environment, which makes the analysis challenging.

As the toxicity, bioavailability and the cycle of environmental contaminants can strongly be influenced by their chemical speciation, in recent years, the importance of speciation analysis has been recognized by the environmental monitoring and assessment community, leading to the development of an increasing number of speciation techniques. The in situ passive sampling technique diffusive gradients in thin films (DGT) as a speciation tool is based on the binding of labile metal species on a resin gel layer via the diffusion through a diffusive hydrogel (agarose or polyacrylamide) using Fick's Law. The concentration gradient built between the bulk solution and the resin gel makes pre-concentration of solutes possible. Using Fick's law, the time-weighted average concentrations of labile metal species can be obtained in situ. This technique has been widely used to assess trace elements such as Cd, Cu, Ni, Pb, Co, Zn in aquatic systems, but never been applied to test PGE elements until now.

The aim of this study was to develop the DGT technique for the assessment of PGE and Hg using two novel resins R14 and R20, which were designed specifically for above elements. This implies that the binding of the PGEs to the resin is strong, irreversible, almost instantaneous and the accumulated metals amounts are well below the capacity of the resin. The method development involves several different steps: 1) selection of an appropriate diffusive gel 2) the selection of an appropriate resin or binding phase for the PGEs and Hg, 3) development of an efficient elution method for the PGEs and Hg from the resin gel, 4) evaluation of the linear response in function of the deployment time, 5) determination of diffusion coefficients for the PGEs and Hg in the diffusive gel, 6) study the selectivity of the tested resins gels, 7) the accumulated metal amount is well below the capacity of the binding gel, 8) fast kinetics of the resins gels.

Agarose diffusive gel (AGA) (1.5% agarose) was chosen for lower interaction with PGEs and Hg, adequate blank values and linear response ($R^2 = 0.99$) in function of the time were obtained for the new resins gels and diffusion coefficients could be determined. An aqua regia and thiourea in hydrogen chloride elution methods gave a recovery for PGEs and Hg over 90% and 80% for the R20 and R14 resins gels, respectively. The selectivity test showed these two resins have higher selectivity to PGE and Hg than other trace elements even though they are at very high concentration level and the analysis of PGEs and Hg by sector field ICP-MS optimized. The new resin gels showed capability of accumulation concentration of PGEs and Hg of each hundred times higher than their reported concentrations in the aquatic environments.

Preliminary deployments in the Zenne River and UZ hospital effluent, Brussels, Belgium, showed that Pt, Pd, Rh and Hg can be quantified by the DGT technique using both evaluated resins in fresh water.

Keywords: DGT; PGEs; Hg; SF ICP-MS; diffusive coefficient; surface water; speciation