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Editorial

Modelling of River Flows, Sediment and Contaminants Transport

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Economic development projects in river basins, involving mining, forestry, agriculture and urban developments, invariably impact the aquatic ecosystems of the basin. To ensure that these projects are sustainable, environmental impact assessments need to be carried out. These assessments in turn require a thorough understanding of river dynamics, sediment production and transport and sediment–contaminant interactions and transport in rivers. The modelling of river flows, sediment and contaminant transport can serve as useful tools for carrying out these assessments. For this special issue, papers addressing these aspects were sought, with special emphasis on river morphology, cohesive sediment transport processes and sediment contaminant interactions. All together five high quality papers were received in response to our request. A summary of all five papers is given here to highlight their contributions to the field.

The first paper [1] is an article by Stone, Krishnappan, Silins, Emelko, Williams, Collins and Spencer. It proposes a new modelling strategy, which integrates four existing numerical models (MOBED, RIVFLOC, RMA2 and RMA4) to model cohesive sediment transport in the Oldman River watershed, in Alberta, and to route the sediment from the upland sources, through three rivers in the plains to a downstream reservoir. The MOBED model is a coarse-grained, non-cohesive sediment transport model and it also calculates the unsteady and non-uniform river flows in one dimension. The RIVFLOC model is a cohesive sediment transport model, which calculates the flocculation of cohesive sediments explicitly in two-dimensional river flows. The RMA2 and RMA4 are reservoir models that calculate the depth averaged velocity components in the horizontal plane and the dispersion and settling of fine-grained sediment in reservoirs. The input data for these models were generated by field measurements carried out in the rivers and reservoir. The models were calibrated and applied using data from the long-term monitoring programs, established in the reference (unburned), and fire impacted watersheds. The model predictions in rivers show that the deposition of fine sediment to the bed occurs not because of the traditional deposition process, but because of the entrapment (ingress of fine material into the coarse substrate) process. Predictions in the reservoir show that the depositional characteristics of burned sediment differ from that of unburned sediment. The predicted depositional patterns show a spatial variation within the reservoir, which can lead to zones of increased internal loading of phosphorus to reservoir water columns, thereby increasing the potential for algae proliferation. Because of the growing threats to water resources due to wildfires, the modelling strategy proposed in this paper can be used to model the propagation of fine sediment and the associated nutrients and contaminants to reservoirs, under different flow conditions and land use scenarios. Therefore, the modelling framework is a valuable tool for water resources management and watershed planning.

The second paper [2] is an article by Jia, Zhou, Shao and Zhang, describing a three-dimensional numerical simulation of fine-grained sediment deposition in a large reservoir in China (Three Gorges Dam Reservoir on the Yangtze River). They employed an existing three-dimensional model of water flow, based on Reynolds' equations, a three-dimensional mass balance equation for sediment transport and deposition and a two-dimensional gravity-driven model of fluid mud, formulated by the authors. The three-dimensional model predicts the sediment deposition in the reservoir, based on flow patterns, sediment

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dispersion and settling, and a mass balance equation calculates the bed level changes during deposition. As the fine sediment deposits on the reservoir bed, the sediment accumulates and forms a fluid mud, with high water content. The fluid mud then flows laterally because of the lateral slope of the bed of the reservoir until it reaches the thalweg (deepest part of the reservoir). In this paper, the authors have formulated a two-dimensional model to calculate the movement of the fluid mud and to redistribute the deposited sediment. Using field measurements of thickness of sediment deposits in the Three Gorges Reservoir, the authors have shown that the computed thickness of the sediment deposits agree well with the measured data. The approach proposed by the authors has the potential to be applicable to sediment deposition in large reservoirs, where the formation of a fluid mud layer is a possible scenario.

The third paper [3] is an article by Datok, Sauvage, Fabre, Laraque, Ouillon, Moukandi N'kaya, Sanchez-Perez, describing the sediment balance estimation of the 'Cuvette Centrale' of the Congo River basin, using the SWAT hydrological model. The Congo River basin is the second largest continuous tropical rain forest in the world and houses the largest peatland complex in Africa. The peatland complex is encircled by the 'Cuvette Centrale', which is a central depression in the heart of the basin. The Soil and Water Assessment Tool (SWAT) is a physically based hydrological model, capable of integrating environmental data, such as climate, soil, land-cover and topographical features, and simulating the hydrological processes, such as surface runoff, infiltration, evapotranspiration, lateral flow, percolation to shallow and deep aquifers and channel routing. The model was run for the period 2000–2012 and calibrated using the measured data from the main gauging station of the basin. The calibrated model was used to estimate the sediment balance for the 'Cuvette Centrale' and found that it acts like a big sink for sediment, trapping up to 23 megatons of sediment produced upstream every year.

The fourth paper [4] is a review article by Krishnappan. It provides a review of a semi-empirical modelling approach for cohesive sediment transport in river systems. Because of the large number of controlling parameters for the transport processes of cohesive sediment, cohesive sediment transport models are invariably semi-empirical, and the model parameters are often measured using a rotating circular flume in the laboratory. One such model, called RIVFLOC, developed by Krishnappan, is reviewed in this paper. The parameters that need to be determined for the application of the model include the critical shear stress for erosion, critical shear stress for deposition, according to the definition of Partheniades, critical shear stress for deposition, according to the definition of Krone, cohesion parameter governing the flocculation of the cohesive sediment and a set of empirical parameters that define the density of the flocs, in terms of the size of the flocs. Measurement of these parameters, using a rotating circular flume, located in the National Water Research Institute in Burlington, ON, Canada, is highlighted in the paper. Application of the RIVFLOC model to different river systems was examined and the resulting parameters for different river systems were compared. The paper concludes that the entrapment process of fine sediment (ingress of fine material into the coarse bed sediment) is an important process that needs to be taken into account when dealing with the cohesive sediment transport in rivers.

The fifth and final paper [5] is by Beltaos and Burrell. This is a review paper and it deals with the effects of river-ice breakup on sediment mobilization and transport. In cold regions of the world, where rivers can freeze during winter months and can flow under intact or broken pieces of ice cover, flows under a solid ice cover can have lower potential for sediment transport, because of the increased boundary resistance and reduced flow velocities. During the breakup of ice covers, on the other hand, a greater potential for the erosion of sediment occurs, due to rising discharge and moving ice and highly dynamic waves that form upon the ice jam release. Under such conditions, sharp increases in suspended sediment concentrations can occur. In this paper, the authors review the basics of river sediment erosion and transport of relevant phenomena that occur during the breakup of river ice, and the datasets of measured and inferred suspended sediment concentrations in different rivers. Possible effects of river characteristics on seasonal sediment supply and the implications of increased sediment supply on water quality and ecosystem functionality were also discussed. The modelling of sediment transport, under the highly dynamic flow conditions that prevail upon and after release of ice jams, by coupling a non-hydrostatic three-dimensional hydrodynamic model, with bed erosion and deposition equations to track the changing bathymetry of the riverbed, is referenced.

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