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Digging navigable waterways through lagoon tidal flats: which short and long-term impacts on groundwater dynamics and quality?

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Coastal lagoons are highly valued ephemeral habitats that have experienced in many cases the pressure of human activities since the development of urbanisation and economic activities within or around their boundaries. One typical intervention is dredging of canals to increase the exchange of water with the sea or for navigation purposes. In order to divert the route of large cruise liners from the historic center of Venice, Italy, the Venice Port Authority has recently proposed a project for the dredging of a new 3-km long and 10-m deep navigation canal (called Marghera-Venice Canal, MVC, in the sequel) through the shallows of the Venice Lagoon. The MVC will connect the passenger terminal located in the southwestern part of the historic center to a main channel that reaches the industrial area on the western lagoon margin. Can the new MVC facilitate saltwater intrusion below the lagoon bottom? Can the release into the lagoon of the chemicals detected in the groundwater around the industrial site be favoured by the MVC excavation? Can the depression waves generated by the ship transit (known as ship-wakes) along the MVC affect the flow and contaminant exchange between the subsurface and surficial systems? A response to these questions has been provided by the use of uncoupled and coupled density-dependent groundwater flow and transport simulators. The hydrogeological modelling has been supported by an in-depth characterization of the Venice lagoon subsurface along the MVC. Geophysical surveys, laboratory analyses on groundwater and sediment samples, in-situ measurements through piezometers and pressure sensors, and the outcome of 3D hydrodynamic and computational fluid dynamic (CFD) models have been used to set-up and calibrate the subsurface multi-model approach. The modelling results can be summarized as follows: i) the MVC has a negligible effect in relation to the propagation of the tidal regime into the subsoil; ii) the depression caused by the ship transit along the MVC is responsible of a groundwater efflux from the canal bottom into the lagoon ranging up to 100 m3 per ship; iii) ship-wakes enhance the release of anthropogenic contaminants (As, Se, Cd, Hg, Pb, Cu, Cr) from the subsoil into the lagoon over few years after the canal excavation; iv) the MVC excavation cut the over-consolidated clay layer marking the Holocene–Pleistocene limit, thus favouring a localized salt contamination of the almost fresh-water aquifers located in the uppermost part of the Pleistocene series.