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Residence time of pollutants is an indicator of health of the Gulf of Kachchh, a macrotidal regime: a numerical study

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The Gulf of Kachchh (GoK), a macro-tidal water body located in the northeastern part of the Arabian Sea, has a length of $\sim$ 180 km and width decreases from $\sim$ 70 km in the mouth to about 1-2 km off Navalakhi near the head; the mean depth being $\sim$ 30m. Across the western open boundary, the Gulf waters interact with the northern Arabian Sea, and in the eastern part, it opens into a shallow creek system called the little Rann of Kachchh. The Gulf of Kachchh is known for its high tidal range and currents; the tidal elevation varies from 3.5 m at the mouth to 7.5 m near the head (Navalakhi). Eco- sensitive areas like Marine Sanctuaries and Marine National Park are located in the southern shore of the Gulf. During the experimental model runs, it was observed that there exists a dynamic barrier across Sikka - Mundra section and this barrier prevents the material released in the eastern GoK from coming out through the mouth. Further, tidal currents in the Gulf have a strong E-W component, which prevents the material from the north from being transported towards south. Therefore, in this work, the residence time is considered as the time required for the mean concentration of a constituent in the GoK to drop to 1/e of its initial value (similar to the study of Abdelrhman (2002).

The residence time measures the effectiveness of tidal flushing of a water body. For studying the pollutant dispersion and estimating the residence time, 8 specific locations (Loc1-Loc8) have been identified in the GoK, and dissolved matter is released numerically at each of these locations at the rate of 100 kg/s at every time step of 60 s. At each location, the average concentration values were noted and time taken for the concentration reduces to 1/e was considered as the residence time. In the regions situated very close to the open boundary (Eg. Locations 1 and 2), where the GoK waters exchange freely with the northern Arabian Sea, dilution takes place rapidly with the incoming water and hence, the residence time is very short, of the order of 1 day, irrespective of any season. Shorter the residence time, well flushed will be the water body. Eastern GoK (Eg. Locations 4 and 8) shows relatively a large residence time, of the order of 2-4 days, and hence, extreme care must be taken when the industrial wastes are released in the eastern Gulf. The region around location 5 behaves like a bay; due to shoals and eddy formation, the dissolved matter gets trapped in the bay, and hence the residence time is higher, of the order of 3-4 days, though it is situated close to the mouth of the Gulf. In spite of GoK being a receiver of pollutants from several industries situated along its coast, it is still unpolluted, and DO is above 5 mg/l - flushing characteristics and shorter residence times are the factors responsible for the health of GoK.