Poroelastic characteristics of seabed sediments in a tidal flat of river mouth

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Two pressure gauges are set at a depth of 1.0 m in seabed sediments and on the sea floor to measure the difference in pressure between the ports to investigate the flow of pore water in the top layer in a tidal flat of river mouth, Takahashi River, Okayama. The pore-water head measured at the depth of 1.0 m is constantly higher by 0.1006 m in average than the seawater level in spite of a large tidal fluctuation with 1.44 m in amplitude. The differential pressure is accompanied with a small periodic fluctuation of 0.0031 m in amplitude, 2.60 hours in phase lag and the same period (12.42 hours) as the tide. Nevertheless, the electrical conductivities of pore water in shallow zones in the tidal flat shows high values similar to that of sea water, indicating sea water intrusion into the sediments. On the ebb tide for about 4 hours, on the other hand, the head of pore water falls down to a depth of about 0.05 m from the ground surface and rises up rapidly in incoming tide, suggesting the formation of unsaturated zone of about 0.15 m thick at low tide. The poroelastic theory (Wang, 2000) is applied to this small change in differential pressure during the submerged periods in order to understand the different phenomena. By comparing the amplitude and the phase lag of the differential pressure with those of tide, following results are obtained: the loading efficiency is 0.9973, the vertical hydraulic diffusivity is 7.3 e-4 m2/s, the specific storage coefficient is 8.5 e-4 1/m, and the vertical hydraulic conductivity is 6.0 e-7 m/s, which can be corresponded to the characteristics of clayey medium. Using the results, the upward flux can be estimated to be in order of 6.0 e-8 m/s. The unsaturated zone formed in ebb tide cannot be occupied by the upward groundwater flow within the period of one tide, because the amount of water table rising is estimated to be in order of 6 e-3 m for the period of tide, if the porosity is assumed to be 0.5. Thus, the seawater must intrude into the unsaturated zone in the next incoming tide. The tope zone of about 0.1 m to 0.2 m in thickness is considered to be replaced by new seawater every tide, whereas very slow upward flow of groundwater could be considered in the deeper zones. In the process forming the unsaturated zone, the horizontal (lateral) flow toward the offshore must break out through the horizontal hydraulic gradient formed as the water edge leave for the offing in the ebb tide, because the vertical flow is very small. Therefore, the lateral hydraulic conductivity can be considered to be much higher than the vertical conductivity for the strata. The heterogeneous formation of shallow zone may consist of horizontally stratified layers of cay and sand. The vertical flow may be restricted by horizontal impermeable clay layers and the horizontal flow is relatively unrestricted by sandy layers. Thus, it is considered that oxygen can be supplied to the top layer by two processes: one is the formation of unsaturated zone by lowering water-table accompanied with air intrusion to the top layer in ebb tide, and the other is the intrusion of seawater containing oxygen to the unsaturated zone in rising tide.