Geophysical Research Abstracts,
Vol. 11, EGU2009-2215-2, 2009
EGU General Assembly 2009
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The role of dunes in contrasting saltwater intrusion in coastal areas; a case study in the southern Po Plain Adriatic coast (Ravenna, Northern Italy)

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Due to climate changes and to anthropogenic interventions, saltwater intrusion is affecting the aquifers and the surface water of the Po plain along the Adriatic coast. During the last decade, we recognized in this area a pattern of climate change: precipitations are less frequent and the yearly amount of rain is concentrated in a few strong storm events. This pattern results in an increase of gales strength during the winter, which causes shoreline retreat and an erosion of the coastal dunes. The coastal part of the Po plain consists of a low-lying and mechanically-drained farmland further from the sea and of a narrow belt of dunes and pine forests in the backshore area. The wide sandy beaches are now retreating and the dune system (only a few meters in height) is almoust destroyed, because of tourism development and of disaggregated rivers and shorelines management.

A still active dune system is preserved in our study area, a coastal plain included between the Fiumi Uniti and Bevano rivers near the city of Ravenna. As a result of an intensive exploitation of coastal aquifers for agricultural, industrial, and civil uses, both the phreatic aquifer and the surface waters have been contaminated by seawater. Despite its value for the natural ecosystem and the agricultural soil, the phreatic aquifer is not considered of interest by the regional authorities responsible for water management.

A detailed hydrogeological survey was performed by our research group during the Summer 2008 within the framework of the CIRCLE-ERANET project WATERKNOW on the effects of climate change on the mediterranean catchments. In this survey 29 auger holes with an average spacing of 350 m where drilled with the objective of determining the top groundwater quality in the coastal aquifer. At the same time, we measured the chemical and physical parameters of the surface waters. The data collected in the field show that a fresh groundwater lens is still present in the aquifer of the backshore area below the coastal dunes and that the surface water is all brackish to salty. Where compared with the elevation map, in fact, the electrical conductivity data (a proxy for salinity) seem to be strongly controlled by topography (even small variations). In the study area, the topographic reliefs consist of several rows of dunes, the topographic lows are artificial ditches and ponds or dune slacks. The farmland is about at the same level of the sea.

In the northern part of the study area, the fresh groundwater lens in the backshore zone is missing, as dunes were eroded (down to 1.5 m above m.s.l.) and a series of saltwater ponds (about 1 m below m.s.l.) are present right behind the active dunes. The central part of the study area is characterised by the presence of a 3 m high active dune and of a large pond in the innermost side of the backshore. In this case, there is a narrow fresh groundwater lens in the active dunes area, whereas inland the aquifer is completely salty up to the agricultural fields. The southern area has the best preserved and tallest dunes (more than 4 m) and do not contain any pond. Here, the fresh groundwater lens is wider than everywhere else and the aquifer becomes salty only where the drainage ditches are causing upconing of deeper salty groundwater.

Our study has recognized the importance of coastal dunes in counteracting saltwater intrusion in the phreatic aquifer. Therefore, it is important to consider measures and interventions in order to preserve the integrity of the dunes not only for the purposes of avoiding shoreline erosion and coastal ecosystem destruction but also for freshwater resources protection. On the other hand, in low lying coastal areas, drainage and the construction of ponds may enhance seawater upconing.