Hydrogeological characterisation of the Flumendosa plain

Claudio Arras[1], Roberto Balia[2], Paolo Botti[4], Cristina Buttau[1], Pierluigi Cau[3], Stefania Da Pelo[1], Antonio Funedda[1], Giorgio Ghiglieri[1], Alfredo Loi[1], Mario Lorrai[4], Maria Teresa Melis[1], Maurizio Testa[5]*

[1] *Università degli Studi di Cagliari, Dipartimento di Scienze Chimiche e Geologiche, Monserrato (CA), Italy.*
**Corresponding email: arrasclaudio@gmail.com*

[2] *Università degli Studi di Cagliari, Dipartimento di Ingegneria Civile, Ambientale e Architettura, Cagliari, Italy*

[3] *Centro di Ricerca, Sviluppo e Studi Superiori in Sardegna (CRS4), Pula (CA), Italy*

[4] *Regione Autonoma della Sardegna, Servizio tutela e gestione delle risorse idriche, vigilanza sui servizi idrici e gestione delle siccità, Cagliari, Italy*

[5] *Agenzia Regionale per la Protezione Ambientale della Sardegna (ARPA Sardegna), Cagliari, Italy*

ABSTRACT

The alluvial plain of the Flumendosa River, in south-eastern Sardinia (Italy), is filled by detritic and alluvial deposits of Upper Pleistocene and Holocene Epoch and hosts a shallow phreatic aquifer and a deeper confined one. The plain is surrounded by hill reliefs made up of metamorphic and plutonic rocks of Palaeozoic Era.

Progressive seawater intrusion and soil salinization have occurred over the last few decades probably due to decreasing surface water supply from the Flumendosa River caused by dam construction upstream the plain and groundwater overexploitation for irrigation and household purposes related to increasing touristic request during summer periods (INEA, 2011).

The EU Water Framework Directive (WFD; 2000/60/EC) and the Groundwater Directive (GWD; 2006/118/EC), implemented by the Italian national regulation in the D.Lgs. 30/09, establishes that all groundwater bodies of member countries must be monitored to assess their quali-quantitative status. The Flumendosa plain represents one of 114 groundwater bodies (GWB) of the Hydrographic District of Sardinia and it is monitored since 2011 by the Regional Environmental Protection Agency of Sardinia (ARPA Sardegna). Since it has been classified in a poor chemical and quantitative status there is the need to better understand the hydrodynamic context and to plan effective remediation actions that will be included in the next update of the River Basin Management Plan of Sardinia (RAS, 2016).

Keywords: Water Framework Directive, 3D geological model, piezometric data

METHODS

A systematic review of various geological, geophysical and hydrogeological data acquired in the last four decades has been performed. These data include 39 stratigraphic logs, 4 seismic reflection

profiles, a gravimetric survey, more than 50 electric geophysics points, piezometric data and hydrogeological parameters from several hydrogeological surveys.
According to the analyses of geological and geophysical data interpreted through the principles of sequence stratigraphy, a 3D geological model of the plain was realised by interpolating 52 geological sections using the software MOVE (Midland Valley).
Groundwater dynamics and response to intense rainfall events and surface water release from upstream dams were investigated by correlating daily piezometric levels measured at three piezometers with daily precipitation and hydrometric data for the period March 2016 – December 2017.

RESULTS

Interpretation of the stratigraphic logs has allowed the identification of seven hydrogeological formations characterised by the following geometrical relationships:
the Palaeozoic basement (basement LB-I) can be considered as an aquiclude even if, locally, groundwater circulation can occur within alteration zones or fracture networks; it occurs at depth ranging from few tens of metres, in the piedmont sector, to more than 400 metres along the coastline.
Upper Pleistocene alluvial fans (aquifer AB) are made of slightly consolidated coarse and fine sediments; in the western and piedmont sector of the plain they host a phreatic aquifer while in its central-eastern sector they deepen and the facies succession changes laterally into the aquiclude AB_{im}; probably, the aquifer AB extends below the AB_{im} but supporting data are missing so far.
Aquiclude AB_{im} is an almost 70 metres thick of argillaceous succession whose upper limit occurs at 50 meters depth below the ground surface in the central and eastern part of the plain.
Holocene alluvium (aquifer AA1 and AA2) is mainly made of coarse fluvial deposits with high hydraulic conductivity values; a shallow phreatic aquifer AA1 occurs along the whole plain while in its central part the occurrence of the aquiclude $AA2_{im}$ generates a locally confined aquifer AA2.
Aquicludes $AA2_{im}$ and $AA1_{im}$ are mainly composed of argillaceous facies with silty and sandy intercalation of lagoon environment; the first one occurs at a depth of 10-15 metres below the ground surface while the second one outcrops in the backshore locally confining the AA1 aquifer.
Daily precipitation and hydrometric measurements were compared to piezometric data from three piezometers intercepting either the aquifer AA1 or AA2. Results have shown that during the wet season significant groundwater level rise occurs for more than 20 mm/day precipitation rates in both the aquifers. During the dry season, when no precipitation occurs, little groundwater level rise could be related to surface water release from dams. Groundwater level rise occurs after a delay time of few days for both precipitation events and dam releases.

CONCLUSIONS

The hydrogeological framework of the Flumendosa Plain is characterised by the occurrence of different aquifer systems locally confined by aquiclude formations. Piezometric data from both the aquifer AA1 and AA2 indicates a generally good response to direct precipitation recharge and river-aquifer exchange. Those results will represent the input data of a groundwater flow numerical model

that will be used for simulating different management scenarios of the groundwater resources capable to restore the good status of the GWB as requested by the WFD.

References

INEA, 2011. Valutazione del rischio di salinizzazione dei suoli e di intrusione marina nelle aree costiere delle regioni meridionali in relazione agli usi irrigui.

RAS, 2016. Piano di Gestione del Distretto Idrografico della Sardegna - http://www.regione.sardegna.it/speciali/pianogestionedistrettoidrografico/