could be considered as subject to human influence. These are assessed from indicator species associated with concentrations which are above a given value. We applied these methods to the 91 groundwater bodies delineated within the Emilia-Romagna region (Italy) in compliance with the EU WFD and D.Lgs 30/2009. The analysis is based on concentration time series recorded at several monitoring locations included in the extensive network of observation wells managed by the ARPA - Regional Agency for Environmental Protection. The groundwater bodies analyzed are located within the following porous aquifer complexes: the Apennine rivers alluvial fans, the floodplains Apennine, Po Valley and coastline. Free surface and confined groundwater bodies have been distinguished. The monitored distributions of Arsenic, Boron, Ammonium and Chlorides were then analyzed within the delineated groundwater bodies. The estimated values of NBLs and TVs indicate that in the cases examined the two methodologies provide comparable results, rendering background concentrations and, consequently, threshold values of the same order of magnitude. Both methodologies lead to estimates of Arsenic NBLs which, in this preliminary study, are not consistent with the observation that the largest arsenic concentrations are found in the deep groundwater bodies and only to a minor extent in the upper aquifers. We conclude that the results of these statistical methodologies should be jointly considered with a profound understanding and quantitative modeling of the physical processes that dominate the (hydro-geo-chemical) space-time evolution of the species analyzed in the groundwater system.

A7-12 Orale Rotiroti, Marco

10.1474/Epitome.04.0103.Geoitalia2011

GROUNDWATER QUALITY CHARACTERIZATION OF CREMONA AREA (NORTHERN ITALY) AFFECTED BY AS, FE AND MN CONTAMINATION, COMBINING HYDROCHEMICAL ANALYSIS AND AQUIFER TEXTURE MODELING

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Key terms: Arsenic; Iron; Manganese; Groundwater contamination; Aquifer texture modeling

This study was developed within the framework of a scientific collaboration between the University of Milano-Bicocca and the Province of Cremona. The main aim is to identify the quality of the groundwater hosted by the multi-layer aquifer of the Cremona area, affected by As, Fe and Mn contamination.
The specific study area is situated near the confluence between the Adda and Po rivers. It covers a 50 km^2 area around the urban territory of Cremona. The considered depth is around 200-250 m, corresponding to Aquifer Group A (Regione Lombardia & ENI, 2002), which hosts in this area both shallow and confined aquifers.
The applied methodology involves the (a) collection of historical data related to water quality, water levels and well logs, (b) storage of collected data in specific databases, (c) construction of a 3D model of the aquifer structure, (d) design and execution of a field survey of water levels and water quality, (e) analysis of the hydrodynamic properties of the system, (f) spatial and time analysis of water quality data considering the hydrodynamic properties and the lithological and textural structure of the aquifer, (g) elaboration of a general hydrogeochemical conceptual model, incorporating some hypothesis about the mechanism and the origin of the contamination.
The 3D hydrogeologic model simulates the textural distribution of the aquifer deposits. It was built by means of kriging interpolation of the percentages of fine (clays, silts, peats), medium (sands) and coarse (gravels, pebbles) deposits, derived from the numerical coding of well data logs. The resulting model underlines the abundance of fine deposits and puts in evidence the significant presence of peat lenses.
The water quality measurements, executed in July 2010, indicate that the groundwater is characterized mainly by a calcium-bicarbonate facies, with higherchloride and sulfate in the shallow aquifer. pH increases with the depth of sampling, ranging from 7.0 to 7.5 in the shallow aquifer and from 7.5 to 8.5 in the deeper aquifers. Redox potential assumes positive values only in the shallow aquifer while in the confined aquifers it has negative values (-100/-200 mV). Conductivity ranges from 300 to 1000 µS and it increases with the depth of sampling. These values indicate a medium/medium-high level of water mineralization.
With respect to the most important chemical parameters, bicarbonates ranges from 200 to 600 mg/L and they increase with depth. The highest bicarbonate values could be generated by the equilibration of the CO_2 derived by the degradation of the organic matter of the aquifer. Nitrates and sulfates increases with the depth of sampling, with higher concenrations of the former than the latter. Ammonia has been detected with low concentrations in the shallow aquifer and generally with high levels (1-5 mg/L) in the underlying aquifers.
Iron and manganese has been measured at high levels: they range respectively from 100 to 6000 µg/L and from 10 to 1200 µg/L. Generally the higher levels has been found in the surficial aquifers. It is possible to identify a decrease of concentration with depth, probably connected to the pH increase.

Arsenic has also been measured at high levels (it ranges from 1 to 180 µg/L) especially in the range of depth of 30-100 m.
Consideration of the textural model and water quality data yield hypotheses regarding the processes which control on the degradation of natural organic matter and its relation to general groundwater quality. Degradation of peat, that can explain the high ammonia levels, is associated with the progressive reduction of O_2, NO_3^-, Mn(IV), Fe(III), SO_4^{2-}, CO_2. These processes could explain the measured high levels of Fe and Mn, but also the high levels of As, which is generally sorbed on the surface of iron and manganese oxides, subject to release during their reductive dissolution.

A7-13 Orale Cremonesi, Daniele

10.1474/Epitome.04.0104.Geoitalia2011

INTERACTION BETWEEN ROCK MOUNTAIN AND ALLUVIAL PLAIN AQUIFERS IN THE SERIO RIVER BASIN (BERGAMO - ITALY)

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Key terms: Hydrogeological balance; recharge; Serio River

Lombardy is one of the most important Italian Regions for availability of water resources, both on surface and underground. However, urban growth, industrial and agricultural spread caused a change in these resources, both in terms of quality and quantity, especially in the alluvial aquifer.
Therefore a correct management of water resources in the plain area assumes a correct comprehension of the recharge processes, in particular the relationship with Prealpine aquifers.
This study purposes to improve the knowledge about the groundwater circulation in mountain and piedmont areas of Lombardy, in order to define the recharge of hydrogeological plain system. To purpose this aim a hydrogeological balance-based method was utilized and applied to the Serio River basin (Bergamo District). The studied area has an extension of about 450 km2 and it is characterized by great difference in altitude (from 361 m a.s.l. in Cene to about 2900 m a.s.l). The Serio River basin mainly consists of carbonate rocks, where large fractured-karst aquifers have developed. The presence of a well developed epikarst layer on surface bring about an important infiltration capacity in all the basin. A number of springs are supplied by this hydrogeological system, among them the most important one is the Nossana Spring, having an average discharge of about 3 m3/s. The waters coming from the Serio River basin supply the plain area enclosed between the Adda and Oglio rivers.
The results obtained by the hydrogeological balance underline that the contribution to recharge of alluvial plain area arising from mountain rock masses is consistent, approximately about 6.5 m3/s, corresponding to 5% of total rainfall. Considering that the amount of water pumped from the alluvial aquifer of the Adda-Oglio basin (90 km2) is about 5.78 m3/s, the recharge coming from mountain aquifer is quite significant.
At regional scale, the contribution of recharge from mountain rock aquifer is more consistent (about 48.5 m3/s), corresponding to the 15% of rainfall and to the 142% of the groundwater drawings.
This result confirms that at the regional scale, the recharge is important to maintain and preserve the plain aquifer.
The hydrogeological balance presented in this study can be the first important step to implement numerical models capable of simulating the water exchanges between the plain and the mountain areas, in order to obtain quantitative information on outflows and relationship between surface and groundwater aquifers. Another possible improvement is to use these models like provisional instruments.
Furthermore, in order to quantify the availability of water resource related to climate change scenarios, neural networks architectures have been built and trained. They are capable to relate the rainfall data (the input to the mountain system) to outputs, separating them in springs flows (for the mountain zone) and water table levels (for the plain area). Operating in this direction, it has been possible to evaluate the effects of climate change on water availability both in mountain and in plain area.

A7-14 Orale Cameron, Enrico

10.1474/Epitome.04.0105.Geoitalia2011

AQUIFER VULNERABILITY: AN ANALYTICAL PERSPECTIVE

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Key terms: acquifer vulnerability; impact; transport equations

Theoretically it should be possible to predict the impact of a polluting event on an aquifer from the knowledge of the aquifer vulnerability and of the features of such event (i.e. chemicals involved, volumes released etc.); the most common vulnerability assessment methods, however, does not allow such a prediction to be made.
Starting from the examination of analytical solutions to transport equations it will be discussed under what conditions and to what extent it is possible at all to properly speak of aquifer vulnerability and how a class of reference vulnerability measures may be constructed.

A7-15 Orale Torrese, Patrizio

10.1474/Epitome.04.0106.Geoitalia2011

GEOPHYSICAL AND HYDROCHEMICAL SURVEYS WITHIN THE STUDY OF THE SALTWATER UPRISING OCCURRING IN THE OLTREPÒ PAVESE PLAIN AQUIFER (NORTHERN ITALY)

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Key terms: saltwater uprising; Vogherese Fault; geophysical survey; VLF-EM; electrical tomography

The alluvial aquifer of the Oltrepò Pavese plain sector (Po Valley, Northern Italy) is characterized by a natural pollution by Na-Cl rich paleowaters (Messinian) that up-rise from the tertiary marine bedrock and mix with the shallow groundwater. This phenomenon is associated to the presence of the "Vogherese Fault", a buried tectonic discontinuity along which the saline waters are mainly distributed. Mapping of these chemically anomalous groundwater is greatly useful. Indeed, extreme mineralization is often a barrier to its use, not only for drinking water supply but also for industrial and agricultural use. Given that saltwaters mapping cannot be undertaken on the sole basis of wells hydro-chemical monitoring as these are often insufficient or absent in some areas, a geophysical survey was carried out. VLF-EM technique was tested to achieve an expeditive mapping of the conductive bodies over the entire area, involving 35 lines for a total lenght of 71 kilometers. Seventeen resistivity depth soundings were undertaken along a cross section of the "Vogherese Fault" to reconstruct the bedrock geometry and the different hydrogeological units. These were undertaken in a sub-area that is considered representative of the entire study area and were necessary for the different geophysical techniques calibration. The geometrical complexity of the contaminated areas located in proximity to the fault, was also studied at the local scale within a selected experimental site, during a more detailed phase of investigations: a resistivity profile, 5 resistivity depth soundings, 5 long spread and 1 short spread 2D-ERT (Electrical Resistivity Tomography) surveys, two 3D-ERT surveys and a closely spaced grid VLF-EM survey were undertaken along an approximately 3000 m long profile crossing the fault zone with a N-S direction and overlaping a significant length of the