Anthropic impact on deep karst aquifer within Torre Guaceto area (Brindisi – Italy)

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Abstract: This work deals with variations of S.A.R. (Sodium Adsorption Ratio) and nitrates concentrations in groundwater of the Apulian aquifer. Some critical zones have been located, their maximum values occur during the irrigation season. The latest investigation on some critical sites confirmed a gradual worsening of groundwater quality.

Key words: aquifer, S.A.R., contamination, anthropic impact.

Introduction

The area in question extends NE of the S. Vito dei Normanni commune, province of Brindisi (Italy). It is sublevel area whose max height is the built-up area of S. Vito dei Normanni (108 m a.s.l.) stretching over some 150 km^2 and bounded by the Adriatic coastline, the "Canale Giancola", a portion of the State Road n° 16, and the road S. Vito de' Normanni – Punta Penna Grossa. In the northern part, behind the coast there is a morphologically depressed zone where groundwater springs form swamp grounds making up the wet land of Torre Guaceto, of a great natural and historical importance.
The hydrographical grid is rather small-sized, runoff discharge to the sea mainly takes place by means of natural rills among which the main one "Canale Reale" which, at sites, often receives waste water from towns and farms along its course.
Soils, with averagely good physical and fertility characteristics fit for irrigation and yielding good – high production standard, have greatly favoured the local main anthropic practice: agriculture. About 80% of the whole extension accounts for vegetable crops whose produce is averagely resistant to salinity, together with other Mediterranean crops such as: olive and vines. Several wells are privately dug to pump groundwater used for irrigation and home consumption. In order to characterise the Apulian carbonate deep aquifer water quality and to assess the impact of anthropic activities on fresh groundwater - intruding seawater balance, hydrochemical data obtained from a four-cycle sampling carried out during the most representative periods of the different moments of groundwater circulation in the area, have been analysed. In particular, space and time variations of the $_{adj}$S.A.R. (Adjusted Sodium Adsorption Ratio) parameter has been thoroughly investigated in each period.

Pedological, hydrogeological and geological outline.

The area under study belongs to the so-called Apulian Platform, basically made up of calcareous and calcareous-dolomitic rocks. Widely outcropping in the SE zone, the carbonate basement with faults NW-SE oriented, locally degrades, at blocks reaching – 40 m a.s.l. In such a carbonate environment resides the only Apulian groundwater resource named "deep aquifer" which, floating on intruding seawater, flows to the Adriatic Sea with low piezometric gradients[1-3].
Transgressively on the Cretaceous carbonate formation, there are calcarenites of Calabrian age, which represent the base end of the "Sedimentary cycle of the Fossa Bradanica"[4].

Conformably with calcarenites, a middle – upper Pleistocene formation is found. It is composed of yellow sands, characterised by considerable side variations of facies and by a base level of marly clays.

To the end of the groundwater circulation the marly clays level, at the base of sands and above calcarenites, represents a sort of barrier to the free discharge of deep aquifer water to the sea, which makes it circulate under confined condition. Near the calcareous and calcarenite deposits, groundwater circulation is phreatic in type, except for a limited area SSW where, because of more compact limestone, water flows under confined condition.

The permeability degree of limestone and calcarenite formations is very variable even at short distance. There is an alternation between higher permeable soils and lower ones, according to strips almost parallel and perpendicular to the coast-line[5].

Deep aquifer, fed by rainwater in the innermost upland plain of the Murgia, discharges to the sea in three main directions. Two of them converge in the coast draining fronts through sub-aerial and submarine springs, and the third is oriented towards the morphologically depressed zone, near the coast where waters raise, gather together and freely flow to the sea.

Soils, sufficiently permeable and poor in organic matter[6], with texture from coarse to medium, are mainly sands, loamy sands and loams. They are mainly spread in the central and south-eastern portion of the studied zone. Subordinately finer-grain soils, such as the clayey and calcareous ones, are mostly found in the western part.

INVESTIGATION PERFORMED AND ACQUIRED DATA

In the area being investigated, some forty observation wells, all privately owned, of both dug and borehole type, have been taken into account. These have been the object of four sampling cycles carried out over one water year and in: 1) June – beginning of water exploitation; 2) July – when massive pumping occurs; 3) October – when exploitation stops and rains start; 4) March – end of groundwater recharge. In order to estimate water quality, for a general evaluation, some parameters such as temperature, pH, salinity, have been directly determined in situ, some others in laboratory.

Owing to physical characteristics of soils in the zone, one deemed necessary to evaluate water quality by Adjusted Sodium Adsorption Ratio. In fact it is known that S.A.R. is extremely important for determining water quality by evidencing that sodium, in it, is likely to replace calcium and magnesium in the soil, thus causing its chemical physical characteristics to worsen.

Values of Adjusted S.A.R. have been mapped so as to obtain areal distribution over each period examined (Fig. 1); each map includes four classes of values of S.A.R., that is[7]: 1) ${}_{adj}$S.A.R.≤10; 2) 10<${}_{adj}$S.A.R.<18; 3) 18<${}_{adj}$S.A.R.<26; 4) ${}_{adj}$S.A.R.≥26.

Maps show how the ${}_{adj}$S.A.R. 18, representing the water quality critical threshold deepens toward inland by forming two "pockets" whose extension varies according to the period examined.

The two "pockets", located in the central and south-eastern part are separated by the "Canale Reale" by its course, shows a main groundwater flowing direction. By their contours the two "pockets" locate and characterise the tract of coast and seawater intrusion preferential directions. Even groundwater flowing direction, located by the "Canale Reale", keeps always well defined in each observation cycle performed.

a) b)

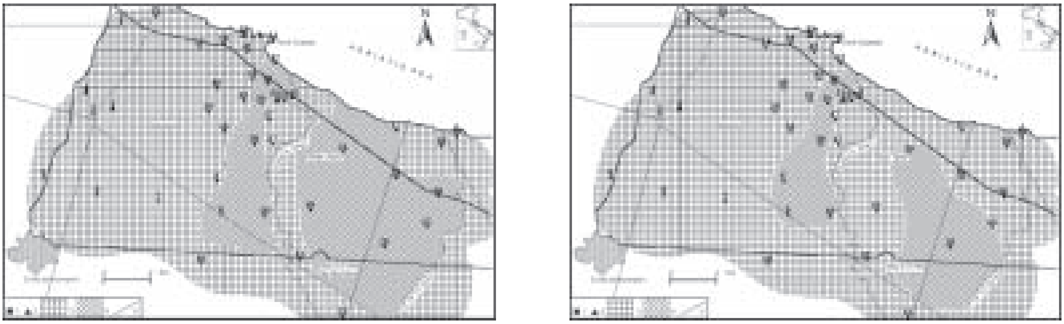
Figure 1. Iso-$_{adj}$S.A.R. of investigation periods.
1) wells; 2) Iso-$_{adj}$S.A.R.; 3) faults; 4) wet zone; 5) springs

With reference to particular periods of the investigation cycles it is evident how the two "pockets", with their development, well define the imbalance evolution of fresh water – brackish water. This results from anthropic activities occurring in the water body during the hydrologic cycle.

By the starting of water pumping and during the top groundwater exploitation, because of the progressive water imbalance caused by pumping, one notices the maximum expansion of the two "pockets" within which the Iso-$_{adj}$S.A.R. 26 (Fig. 1a). At the end of the irrigation season (September) and the accompanying start of recharge period (end of October), groundwater gradually recovers its quality. At the end of recharge (March) the evolution of the Iso-$_{adj}$S.A.R.18 becomes very limited again so that the south-eastern "pocket" does not include the Iso-$_{adj}$S.A.R. 26 (Fig 1b). It is clear that such a recovery is influenced by the amount of the new water contribution and by the fresh water – brackish water imbalance caused by water pumping during summer.

The drop in water quality is also confirmed from maps of nitrates concentration through which one is able to evaluate space-time variations of these salts in water. It is known that nitrates are very mobile due to both their solubility and their lack of interaction with the organic matter and with the particles of soil. This implies that the quantity of nitrogenous fertilizers, which are not absorbed by cultivated lands, is partly exposed to transformation processes and partly leached by irrigation water and conveyed into groundwater. In the zone, irrigation starts around half-May and nitrates concentration found in the four sampling cycles show the effects produced by irrigation apart from the different degree of vulnerability of cultivated lands (Fig. 2).

In June one can notice (Fig. 2a) that the area investigated is characterised by two far-reaching zones, one in the centre and one in the SE portion where nitrates concentrations in water exceed 50 mg/l and some points exceeding 100 mg/l. Investigations have also evidenced that more than 70 % of the water sampled in this period have M.A.C. (Maximum Allowable Concentration) of nitrates higher than those provided for in law. In March (Fig. 2b), the two zones with the highest nitrates concentration considerably shrink, though wells with concentrations out of law account for 32 %.



a) b)

Figure 2. Distribution of NO_3 concentrations in June (a) and March (b).
1) wells; 2) springs; 3) NO_3 < 50 mg/l; 4) NO_3 > 50 mg/l; 5) faults.

CONCLUSIONS

The particular features of the Apulian carbonate aquifer and some aspects of its vulnerability have been located in a coastal zone partly subject to naturalistic lands. In particular the analysis of space-time variations of $_{adj}$S.A.R., not only has it allowed the determination of the main intruding seawater directions but it has also characterised the fresh-water seawater imbalance caused by water pumping for irrigation use.
Moreover, the presence, even at the end of groundwater recharge period, of two well-defined zones, with $_{adj}$S.A.R. values equal to or higher than 18 (critical threshold), proved the progressive impoverishment of the water resource; the progressive worsening of water quality also owing to the persisting presence of nitrates whose concentrations exceed those provided for in law.

REFERENCES

[1] COTECCHIA, V. (1977): *Studi e ricerche sulle acque sotterranee e sull'intrusione marina in Puglia.* C.N.R. - Istituto di Ricerca sulle Acque, 20, Roma.

[2] *Grassi, D., Tadolini, T.* (1985): Hydrogeology of the Mesozoic carbonate platform of Apulia (South Italy) and the reasons for its different aspects. *International Symposium on karst water resources*, Ankara.

[3] GRASSI, D., TADOLINI, T., TAZIOLI, G. S., TULIPANO L. (1977): Ricerche sull'anisotropia dei caratteri idrogeologici delle rocce carbonatiche mesozoiche della Murgia nord - occidentale. *Geol. Appl. e Idrogeol.*, 12, Bari.

[4] CIARANFI, N., PIERI, P., RICCHETTI, G. (1992): Note alla carta geologica delle Murge e del Salento (Puglia centromeridionale). *Estr. Mem. Soc. Geol. It.*, 41, Roma.

[5] SCIANNAMBLO, D., SPIZZICO, M., TADOLINI, T., TINELLI, R. (1992): Lineamenti idrogeologici della zona umida di Torre Guaceto (Br). *Conv. naz. Giovani ricercatori in Geol. Appl.*, Viterbo.

[6] LOPEZ, G. (1971): Studio dei terreni agrari della provincia di Brindisi. *Estr. Annali Ist. Sper. Agr.* Vol. II, 2,10, Bari.

[7] MINISTERO DELLE POLITICHE AGRICOLE E FORESTALI (2001*): Metodi di analisi delle acque per uso agrario e zootecnico*. Coordinatore G. Mecella, Franco Angeli Ed., Roma.