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KARST DEVELOPMENT

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MANAGEMENT OF WATER RESOURCES IN KARST ENVIRONMENTS, AND NEGATIVE EFFECTS OF LAND USE CHANGES IN THE MURGE AREA (APULIA, ITALY)

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Abstract – Karst hydrology is dominated by limited surface runoff, which represented the main problem faced by man from the first historical phases of settlements. Man was however able to develop techniques to collect the available water resources, and adapted his way of life to the karst environment, reaching a sustainable use of the water resources. In the last centuries attention paid by man to the need of the environment has dramatically changed, with immediate negative consequences. Several anthropogenic actions have caused heavy changes in the natural landscape, with effects as increased erosion and flash floods.

Keywords: Karst environment, Italy, Murge karst

INTRODUCTION

Karst environments are among the most fragile settings of the world, extremely vulnerable to a number of degradation events (Ford & Williams, 2007; Parise, 2010). Paying no attention to karst features results in a poor land management, both at the surface and underground, as repeatedly observed on the occasion of the frequent episodes of pollution which are at the origin of severe damage to the natural environment and the karst ecosystems (Parise & Pascali, 2003).

Considering karst aquifers, FAO (the Food and Agriculture Organization of the United Nations) forecasts that before 2025 at least 80% out of the demand of drinkable water in the Mediterranean Basin will be provided by karst aquifers. There is, therefore, an urgent need to adequately protect them by any pollution event likely to affect water quality (White, 1988, 2002; Bakalowicz, 2005). Protection of karst environments is a mandatory step to maintain, safeguard and transmit its extreme richness and biodiversity to the future generations (Parise & Gunn, 2007).

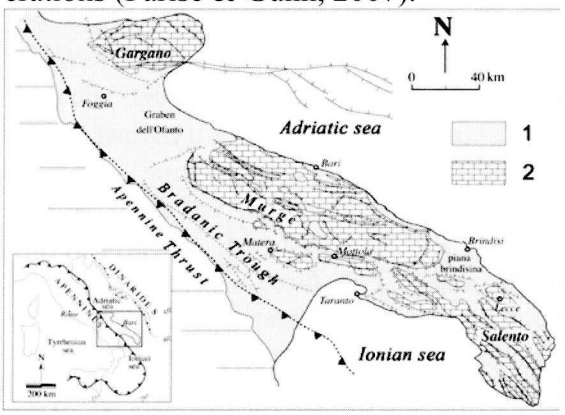

Figure 1. *Geological sketch of Apulia (modified after Pieri et al. 1997): 1) Bradanic Trough sediments and terraced deposits (Pliocene-Pleistocene); 2) carbonate units of the Apulian Foreland (Mesozoic-Cenozoic). The three main karst areas of the region (Gargano, Murge, and Salento) are shown.*

In Italy, Apulia represents an important karst area. Its geologic features, combined with geography (narrow and elongated peninsula between two seas), and morphology (low-relief, undeformed foreland), make the region highly vulnerable to landscape changes. Quarrying and

agricultural practices are the human activities more dangerous to karst. As regards agriculture, even old practices such as clearing stones from the fields have reached in recent years a heavy impact, with disastrous effects on the landscape. In this article, the attention is focused on the Murge area (Fig. 1), one of the most significant karst sector of the region.

LAND USE CHANGES IN THE KARST OF MURGE (APULIA, SOUTHERN ITALY)

Among the most peculiar characters of karst is the presence at the outcrop of bare rock (Fig. 2), or its coverage by thin layers of residual materials. In those areas where a greater amount of clays is present, slightly-defined karst valleys, locally called "*lame*", are formed. These originally were the only sectors where it was possible to perform agricultural practices (Parise et al., 2003). Low relief of *lame* makes them very easy to be canceled from the landscape.

Figure 2. *Murge karst landscape, with outcropping of bare rock.*

As concerns hydrology, *lame* represent most of what is left of the original surface drainage network. They become reactivated, that is interested by runoff, on the occasion of the most significant rainstorms, whilst appear to be dry most of the year. Due to the carbonate setting, and the exposure of bare rocks, there is generally no real water flow system at the surface, with water rapidly infiltrating underground through the network of karst fissures and conduits in the rock mass.

From a geomorphological standpoint, the Apulian Murge are characterized by typical karst surface landforms, mainly dolines with poligonal shapes and diameter generally variable from a few tens to some hundreds of meters. They were presumably originated during the Upper Tertiary under wet-humid climatic conditions (Sauro, 1991; Parise, 2011). The present situation derives from their partial dismantling by erosion, which occurred in Pleistocene time.

In the Murge highplain a high number of mostly vertical caves are present, showing deep shafts, generally controlled in their development by tectonics. Many caves have been lost in the last decades, due to intense quarrying activity, and diffuse stone clearing and crushing practices (Giglio et al., 1996; Canora et al., 2008). Several accesses to karst caves have been clogged with the material deriving from stone clearing in the surrounding fields, whilst other caves have been destroyed by quarry advancement (Formicola et al., 2010). Damage to karst is still on going, without any concern for the karst ecosystems.

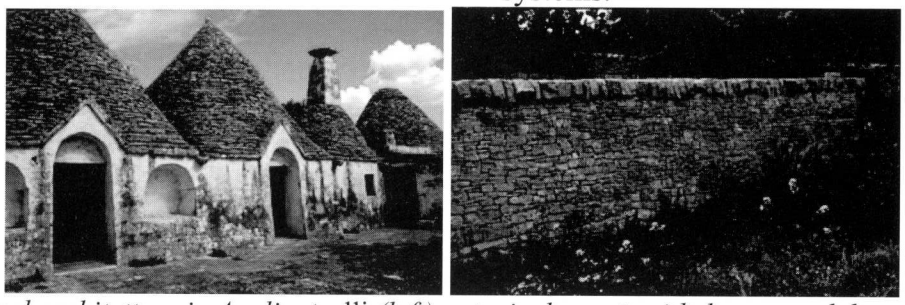

Figure 3. *Rural architetture in Apulia:* trulli *(left), a typical countryside house, and dry-stone walls (right).*

Stone clearing had always been a diffuse practice in many territories of southern Italy, aimed at obtaining wider areas for agriculture. In the past, it was performed manually by farmers, and the resulting material was used to build the typical rural houses or the dry-stone walls (Fig. 3). The latter, a fundamental element of the Apulian countryside, had many functions. They were the boundaries of fields and properties, at the same time helping in controlling the movements of the flocks; dry-stone walls were also used to terrace, functional to reduce or stop the erosion, and to provide greater stability to the slope. Further, they had a crucial function in collecting the rainfall, in territories characterized by medium-low amounts of precipitation. The concave shape of their transversal profile was able to collect at the site a certain amount of water (Fig. 4). Dry-stone walls acted as condenser of atmospheric vapor, collecting daily water that, once transferred to the soil, contributed to feed bush and plants in its proximities. Further, condensation water within the dry-stone walls was not affected by evaporation, because of the temperature increase during the day.

In the last decades the use of modern machineries and technologies to clear the fields from stones greatly increased, even thanks to disputable codes from the European Community, addressed to land use changes, and which were applied in Apulia without taking into consideration the peculiarities of karst environments. Many hectares of land have been extensively cleared, large amounts of rock extracted from the soil, crushed and disseminated to create a new "soil". In many cases, once produced the land use change, pieces of land were eventually abandoned, without harvesting the fields. Wide sectors of Murge have thus lost the original landscape, whilst great volumes of rocks have been dumped into caves, or accumulated around swallow holes, creating serious danger to cavers.

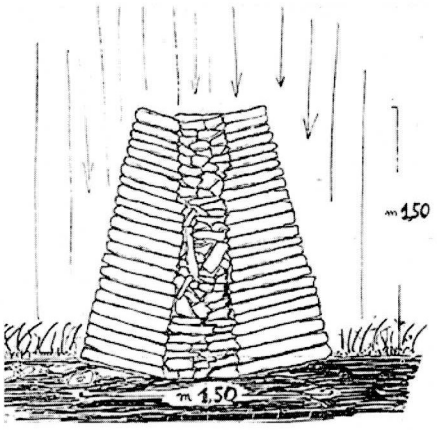

Figure 4. *Transversal profile of a dry-stone wall (modified after Cantelli, 1994).*

In addition to destruction of caves, the main negative effect of stone clearing is the loss of the epikarst (Williams, 1983, 2008). Even though epikarst is generally quite thin, it provides a vital function for karst ecosystems, governing water infiltration underground, and its absorption as well. Destroying epikarst, the removal of the individual soil particles by wind, rain, and runoff is strongly favored, even in very low slopes. This is at the origin of increase in the erosional rate, and may promote a tendency toward desertification, as already registered in many Mediterranean countries (Yair, 1983; Rejec Brancelj, 1998; Sharma, 1998; Frumkin, 1999; Manzano & Navar, 2000).

The remnants of the original surface hydrologic karst system are also lost as a further effect of destruction of the epikarst. As previously mentioned, this system (mostly consisting of *lame*), is very shallow and easy to be disturbed by anthropogenic changes to the landscape. Among the main consequences, development of erosional processes, even on low slopes, and floods had to be registered with an increasing frequency in the last twenty years (Parise, 2003; Andriani & Walsh, 2009).

CONCLUSIONS

The low-relief karst of Apulia has been deeply changed in the last decades as a

consequence of intense human activities which developed without taking into account the peculiarities of the karst setting. Differently than in the past, when man was able to understand the local environment through observations and direct experience, and to reach a sustainable development, we are at present destroying large sectors of the natural karst landscape, spoiling the resources therein contained. Unfortunately, such practices are not limited to Apulia, but widespread in many karst areas of the Mediterranean Basin.

REFERENCES

Andriani G.F. & Walsh N. (2009) An example of the effects of anthropogenic changes on natural environment in the Apulian karst (southern Italy). Environmental Geology, 58, 313-325.

Bakalowicz M. (2005) Karst groundwater: a challenge for new resources. Hydrogeol. J., 13, 148-160.

Canora F., Fidelibus M.D., Sciortino A. & Spilotro G. (2008) Variation of infiltration rate through karstic surfaces due to land use changes: a case study in Murgia (SE Italy). Eng. Geol., 99, 210-227.

Cantelli C. (1994) Misconosciute funzioni dei muretti a secco. Umanesimo della Pietra, 9, 21-27.

Ford D.C. & Williams P. (2007) Karst hydrogeology and geomorphology. Unwin Hyman.

Formicola W., Gueguen E., Martimucci V., Parise M. & Ragone G. (2010) Caves below quarries and quarries above caves: problems, hazard and research. A case study from southern Italy. Geol. Soc. America Abs. with Program, 42 (5).

Frumkin A. (1999) Interaction between karst, water and agriculture over the climatic gradient of Israel. Int. J. Speleol., 26 B (1/4), 99–110.

Giglio G., Moretti M. & Tropeano M. (1996) Rapporto fra uso del suolo ed erosione nelle Murge Alte: effetti del miglioramento fondiario mediante pratiche di ''spietramento''. Geol. Appl. Idrog., 31, 179–185.

Manzano M.G. & Navar J. (2000) Processes of desertification by goats overgrazing in the Tamaulipan thornscrub (matorral) in northeastern Mexico. J. Arid Environ., 44, 1–17.

Parise M. (2003) Flood history in the karst environment of Castellana-Grotte (Apulia, southern Italy). Natural Hazards and Earth System Sciences, 3 (6), 593-604.

Parise M. (2010) Hazards in karst. In: Bonacci O. (Ed.), Proc. Int. Interdisc. Conf. "Sustainability of the karst environment", Plitvice Lakes (Croatia), 23-26 Sept. 2009, IHP-UNESCO, Series on Groundwater, 2, 155-162.

Parise M. (2011) Surface and subsurface karst geomnorphology in the Murge (Apulia, southern Italy). Acta Carsologica, 40 (1), 79-93.

Parise M. & Pascali V. (2003) Surface and subsurface environmental degradation in the karst of Apulia (southern Italy). Environ. Geol., 44, 247-256.

Parise M. & Gunn J. (Eds.) (2007) Natural and anthropogenic hazards in karst areas: Recognition, Analysis and Mitigation. Geol. Soc., London, Sp. Publ. 279, 202 pp.

Parise M., Federico A., Delle Rose M. & Sammarco M. (2003) Karst terminology in Apulia (southern Italy). Acta Carsologica, 32 (2), 65-82.

Pieri P., Festa V., Moretti M. & Tropeano M. (1997) Quaternary tectonic of the Murge area (Apulian foreland - Southern Italy). Annali di Geofisica, 40 (5), 1395-1404.

Rejec Brancelj I. (1998) Influence of modern farming on karstic landscapes. Acta Carsologica, 27/1(3), 201–213.

Sauro U. (1991) Il carsismo delle Alte Murge (Puglia, Italia). Itinerari Speleol., 5, 67-71.

Sharma K.D. (1998) The hydrologic indicators of desertification. J. Arid Environ., 39, 121–132.

White W.B. (1988) Geomorphology and hydrology of karst terrains. Oxford Univ. Press.

White W.B. (2002) Karst hydrology: recent developments and open questions. Eng. Geol., 65 (2-3), 85-105.

Williams P.W. (1983) The role of subcutaneous zone in karst hydrology. J. Hydrol., 61, 45–67.

Williams P.W. (2008) The role of the epikarst in karst and cave hydrogeology: a review. Int. J. Speleol., 37 (1), 1–10.

Yair A. (1983) Hillslope hydrology, water harvesting and areal distribution of some ancient agricultural systems in the northern Negev Desert. J. Arid Environ., 6, 283–301.