ENVIRONMENTAL QUALITY OF DEEP GROUNDWATER IN THE LESSINIAN MASSIF (ITALY): SIGNPOSTS FOR SUSTAINABILITY

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ABSTRACT

Groundwater conservation and management planning in the Lessinian Massif (Veneto, Italy) is herein discussed following an ecological approach dealing with stygobiont species. The aim was to provide baseline signposts for the sustainable management of groundwater sites in order to guarantee the preservation of the stygobiota. The approach is organised in the following steps: 1) groundwater biodiversity assessment; 2) selection of priority sites for conservation; 3) selection of respect zones for the priority sites; 4) evaluation of the main anthropogenic risk drivers; 5) assessment of aquifer intrinsic vulnerability; 6) evaluation of risk; 7) proposal of sustainability signposts.

KEYWORDS : AQUIFER VULNERABILITY, COPEPODS, RISK, STYGOBIONT, SUSTAINABILITY.

1. INTRODUCTION

In the document about the sustainable use of groundwater worked out by RIZA/RIVM (1991) for the EU Minister, groundwater sustainability was hung on two conditions: 1) no loss of groundwater potential functions; 2) preservation of ecosystem diversity and maintenance of species richness. However, the conception that groundwater is not only important in supporting human welfare, but also in harbouring different taxa, belonging to several phylogenetic lineages (Danielopol *et al.*, 2004), is not yet well recognised at political level. The EU enforced the protection of groundwater environments via a number of Directives which mainly give recognition to anthropic aspects (91/271/EEC; 91/676/EEC; 2000/60/EC). The 2000/60/EC Directive and the proposed EU Groundwater Directive 2003 both require the achievement of a good "groundwater status" and the protection/restoration of groundwater bodies with extensive monitoring programmes, completely ignoring their ecological status (Danielopol *et al.*, 2004). Hence, although the concept of sustainability has been introduced in the European Directives, the misconception about the meaning of sustainability still remains. What is needed is the overall awareness that a sustainable groundwater use can only be achieved if groundwater management is part of an integrated approach, directed toward the maintenance of groundwater potential functions and biodiversity (Notenboom, 2001).

Consequently, a possible strategy for obtaining sustainability is the use of a general protection framework, which takes into account the multifunctional features of the groundwater resources, as supplies for anthropic uses and repository of groundwater biodiversity. Moreover, the protection framework should foresee a logical approach in accordance with different environmental pressures and/or sensitivities per country and/or region (Notenboom, 2001). The present contribution falls in this context and the final objective is to suggest some sustainable management practices of groundwater resources in the Lessinian area (northern Italy). The approach allows an analysis of risk that Lessinian aquifers will be likely to experience. The study was organised in the following steps: 1) groundwater biodiversity assessment; 2) selection of priority sites for conservation; 3) selection of respect zones for the priority sites; 4) evaluation of the main risk drivers; 5) assessment of aquifer intrinsic vulnerability; 6) evaluation of risk; 7) proposal of sustainability signposts.

2. MATERIALS AND METHODS

2.1 Study area

The Lessinian Mountains are a 472.14 km^2 trapezium-shaped massif, located in the Venetian Pre-Alps (Veneto, Italy). The massif extends southward in divergent finger-like ridges, branching and entering in contact with the alluvial plane of River Adige. Minor valleys between the ridges are narrow and steep in the northern sector and, in general, wide and smoothly sloping in the southern one (Fig. 1). The composition of the massif is dominated by limestones of Mesozoic and Cenozoic ages, interspersed by Cenozoic volcanic rocks and Eocenic limestone outcrops (Sauro, 1973). Quaternary alluvial deposits fill up the valleys and cover the whole plane. The alluvial thickness is variable, ranging from 100 to 200 m. The flow in the karstic network is characterised by high speed and short travel-time and the hydrological supply is exclusively vertical, deriving from rainfalls which tend to infiltrate vertically in few hours to a maximum of few days. The fast subterranean karstic circuit presents a renewal of about 2-4 months. The subterranean flow direction of the whole Lessinian basin is from north to south and parallel to the minor valleys direction. The total subterranean discharge is quantifiable in about 50 m^3/s: 15 m^3/s flow at the contact between limestones and the alluvial sediments; 30 m^3/s through the streambeds and 5 m^3/s at the karstic outlet of Montorio (Pasa, 1954; Sorbini, 1993; Patrizi and Lavagnoli, 2001).

2.2 Sampling strategy

A stratified random sampling was performed in a macro-scale approach in the lower part of the Lessinian Massif covering an area of about 150 km^2. While some water from the regional aquifer is used for livestock watering, domestic supply and industrial purposes, the main water use, in the investigated area, is for irrigation.

The survey was carried out from June to July 2002 during the low hydrogeological regime when the annual precipitation is about 100 mm vs. 300 mm in October-November (Patrizi and Lavagnoli, 2001). Two saturated strata were selected according to the aquifer typology: a karstic stratum (K) and a porous stratum (P). Spatial distribution of fauna and environmental parameters were investigated from a network of 76 cased wells, following a standardized methodology (Malard *et al.*, 2002). Wells were sorted out randomly in each stratum: 29 wells were selected in the karstic stratum and 47 wells in the porous one which is more widely represented in the lower part of the massif. Wells depth ranged from 4 to 375 m and water level from 0 to 230 m below ground surface. The investigated wells were sealed and cased, being provided of a steel, PVC or hydraulic cement casing perforated in the saturated zone with slots of at least 3 mm, closed on the top and equipped with a submerged pump connected to an engine. The wells were sampled once; before pumping, the water level was measured by an electrical water level meter. A quantitative volume of 500 l of water was pumped and filtered through a 60-µm mesh net at the outlet of the discharge pipes: the filtered sediment was collected in plastic vials and the biological component fixed with 7% formaldehyde solution. Per each sampling site, the following chemico-physical analyses were carried out: temperature, pH, dissolved oxygen, saturation oxygen, electrical conductivity, calcium (mg/l) and total hardness (mg/l) were measured in the field; magnesium (mg/l) concentration was determined by difference by standard methods. Water samples for the

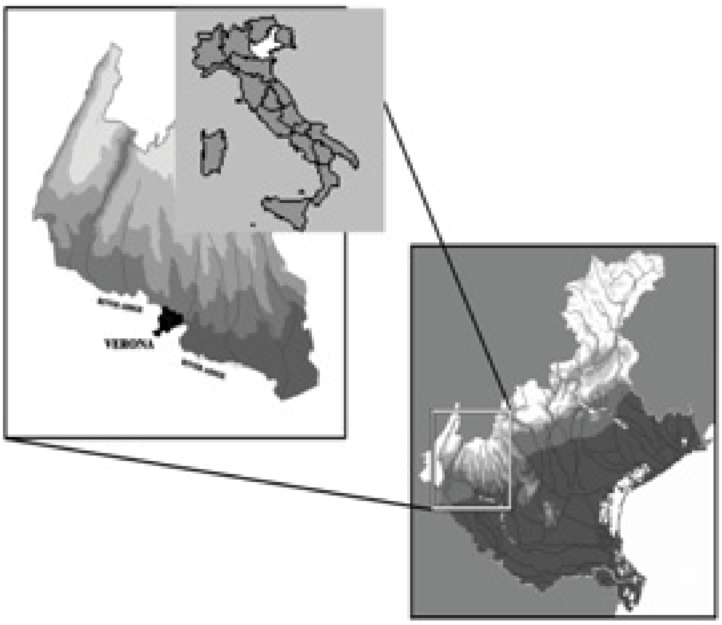

Figure 1 : Map of the Lessinian Mountains (Italy), showing in detail the study area.

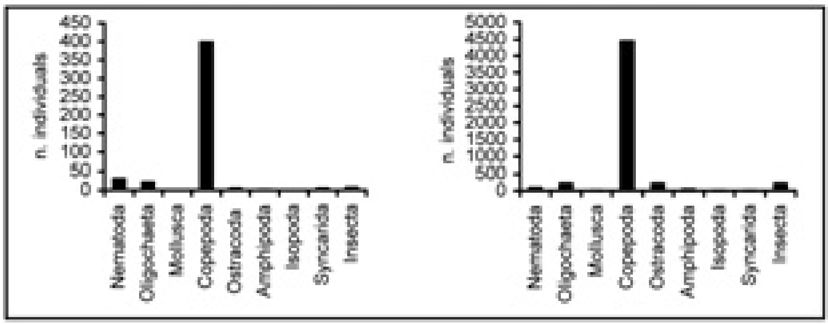

Figure 2 : Abundance of taxa collected in karstic (left) and porous (right) aquifers.

determination of nitrate and phosphate were poured in plastic bottles, twice washed with deionised water and rinsed with pumped water. Nitrate (mg/l) and total phosphate (mg/l) concentrations were measured by a HACH DR 2000 spectrophotometer. Biological samples were hand-sorted under a stereomicroscope and the collected speciments belonging to different taxa (Nematoda, Oligochaeta, Mollusca, Copepoda, Ostracoda, Amphipoda, Isopoda, Syncarida, Insecta) were stored in separated vials and preserved in 70% alcohol solution and identified at species or subspecies level, whenever possible.

3. DATA ANALYSIS AND RESULTS

3.1 Groundwater biodiversity assessment

The composition of faunal assemblages was analysed in order to assess the number of stygobiont species in the saturated Lessinian aquifers. As frequently observed in groundwater habitats, Crustacea Copepoda were the most abundant and species richest taxon. In the investigated groundwater sites, copepods represented the 90% and 84% of the biological samples collected respectively in karstic and porous aquifers (Fig. 2).

Focusing on the frequency of occurrence, copepods showed the highest incidences in both karstic and porous aquifers (Fig. 3).

According to these observations, copepods were selected as focal group, *sensu* Hammond (1995), of the investigated communities and the following analyses were focused on this taxon only. According to the degree of adaptation to groundwater life and by integrating the definitions given by Notenboom (1991), Gibert *et al.* (1994) and Galassi (2001), copepods were classified as stygobionts (Sb), stygophiles (Sp) and stygoxenes (Sx). In order to minimise misinterpretation errors, the use of the wider stygophile concept, considered as potential intermediate evolutionary step in the "stygobitization" process (Stoch, 1995), was avoided and the Sp attribute was limited to the eustygophile species. As expected, stygobiont species were dominant in both karstic and porous aquifers, representing more than 60% of the taxocoenosis and occurring with 12 species vs. a total of 19.

3.2 Selection of priority sites

The selection of priority sites/aquifers took into account the Intrinsic Biological Value (I.B.V.) of the investigated sites independently from other

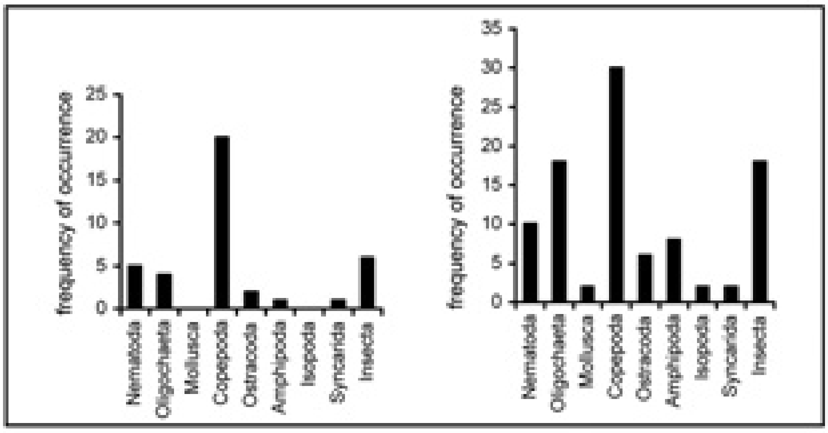

Figure 3 : Frequency of occurrence of taxa collected in karstic (left) and porous aquifers (right).

considerations (De Broyer *et al.*, 2004). The I.B.V. of a site was computed by summing the Conservation Value (C.V.) of each collected stygobiont species/subspecies. The C.V. was computed through an algorithm which averages the value of the following stygobiont species features: endemism, rarity, habitat selection, taxonomic isolation (Stoch *et al.*, 2004). Twelve stygobiont copepod species were collected in the Lessinian aquifers. In Appendix, the C.V. of each species is reported together with the I.B.V of the sites in which at least one copepod species was found. In order to preserve the 12 Sb species, a network of priority sites was identified. The criterium utilised for detecting the priority sites forming the network consisted in: 1) ordering the priority sites in function of decreasing values of the I.B.V. (as in Appendix); 2) selecting the priority site with the highest I.B.V. value; 3) selecting a second priority site with the highest I.B.V. value and harbouring one or more stygobiont species not harboured in the previous selected site; 4) selecting a third, a forth, etc. priority site until completing the entrance of all stygobiont species. In the study case a network of 9 priority sites was selected (Appendix). Results hereafter illustrated deal with three of the priority sites (P6s, P9p, K13p).

3.3 Selection of respect zones around the priority sites

Following the Directive 92/43/EEC, the protection of a species may be realized by the preservation of the habitat in which it lives. Habitat preservation is here defined as the maintenance of the chemico-physical and structural features, through the application of management actions including interdictions, limitations and duties. As the groundwater systems (both karstic and porous) are characterised by a physical and hydrogeological continuity, the best choice in order to preserve groundwater habitats would be to safeguard the whole recharge basin. This option may be excessive for porous aquifers which are self-protected by low permeable sediments, while it seems more appropriate for the karstic ones. As a consequence, two different criteria are hereafter proposed.

The criterium selected for porous sites P6s and P9p consisted in the identification of a Restricted Respect Zone (R.R.Z.) as defined by the Italian normative (Repubblica Italiana, 1999: D.Lgs. 152/99). Following the law recommendation, the isochrone of 30 days was considered the most sustainable one for delimiting the R.R.Z. The sites P6s and P9p are located in two different alluvial valleys of the Lessinian area (respectively Squaranto and Valpantena valleys) at 57 and 88 m a.s.l. and are utilised for irrigation. The depth of the wells is 18 m (P6s) and 42 m (P9p) respectively. According to the hydrogeological parameters, the permeability of the porous medium was estimated about 10^{-4} m/s for both sites. According to permeability and transit-time values (30 days), the radius of the R.R.Z. resulted to be 259 m and the area about 10 km^2 for both P6s and P9p. Indeed, the R.R.Z. was thought as a semi-circle oriented along with

Figure 4 : Topographic map indicating the location of P9p (dot on the left) and K13p (dot on the right) sites. Black arrows indicate the subterranean flow direction. The R.R.Z. (Restricted Respect Zone) and the recharge area of the karstic site are reported too. The thick white arrow indicates the Pantena stream (scale 1:10000).

	P6s	P9p	K13p
	P	P	P
Water exploitation (agriculture)	1	1	1
Nitrates leaching (agriculture)	1	1	1
Pesticides leaching (agriculture)	1	1	1
Sewage leakage (urbanisation)	0.5	0	0
Motorways oil seeping (urbanisation)	1	1	0.5

Table 1 : Risk drivers and P (impact probability) of the selected priority sites.

the main subterranean flow direction (the R.R.Z of the P9p site is represented in Fig. 4). The karstic site K13p (depth = 50 m) is located at an altitude of 76 m a.s.l., at the base of a Cenozoic calcareous hill of about 400 m of height and is utilised for irrigation. The recharge area to be protected was estimated to be about 4 km^2 and no preferential infiltration pathways (eg., sinkholes) were identified for 2 km around the site (Fig. 4).

3.4 Evaluation of the main risk drivers

Risk drivers are the underlying causes which lead to environmental negative impacts. In this section a check-list of drivers is provided together with the probability of occurrence of the negative impacts which may be produced. The drivers were identified through information which resulted from field recognitions and local authorities database. Five risk drivers were identified, due to agriculture (water exploitation, nitrates leaching, pesticides leaching) and to urbanisation (sewage leakage and motorways oil seeping).

In Table 1, the risk drivers are reported together with the probability of the correlated impacts. The probability (P) assumed the values 0, 0.5 and 1, which respectively correspond to a low, medium or high probability of the impact.

3.5 Assessment of aquifer intrinsic vulnerability

The Intrinsic Vulnerability (I.V.) refers to the intrinsic characteristics of the aquifer and in particular to its own aptitude of swallowing and spreading a contaminant infiltrated from the surface (Civita, 1994). Thus defined, I.V. is distinct from pollution risk which depends on I.V. and also on the existence of a significant pollutant loading entering the subsurface environment. More in detail, I.V. increases when the aquifer is interested by the presence of surface water fast-infiltration pathways (as sinkholes or gravel layers) which allow the entrance of pollutants in the saturated zone and act as preferential pathways for the epigean fauna, as well. As a consequence, stygoxene species may be collected at very elevated depth

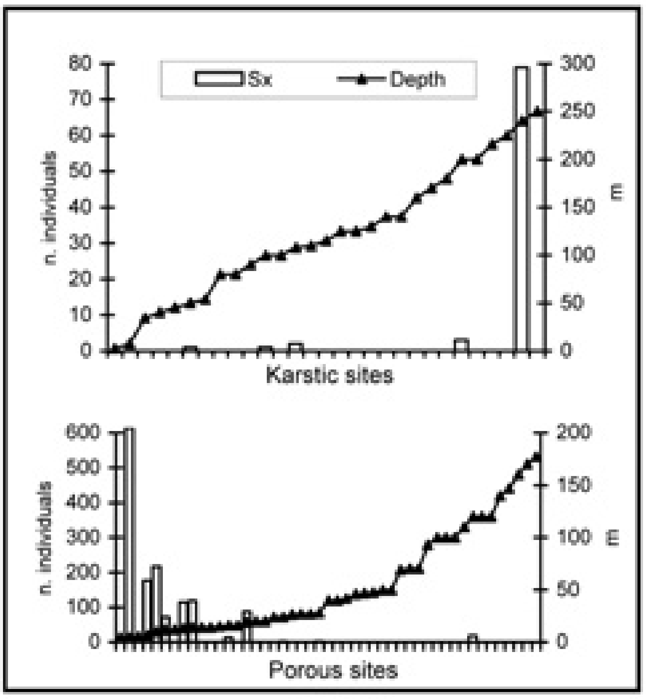

Figure 5. : Abundance of stygoxenes (Sx) along with aquifer depth.
On the horizontal axis, sites are ordered from the shallowest one to the deepest one.

	T	Cond.	O_2	O_2	pH
	(C°)	mS/cm	mg/l	%	
K	14.3 ± 1.5	0.669 ± 0.136	5.7 ± 1.5	58.8 ± 16.0	7.1 ± 0.2
P	15.0 ± 2.5	0.765 ± 0.203	4.7 ± 2.3	48.8 ± 23.4	6.9 ± 0.3
	1.5.1.1.1	NO_3	Ca	Mg	
	mg/l	mg/l	mg/l	mg/l	
K	0.09 ± 0.07	28.1 ± 15.7	71.3 ± 21.6	21.2 ± 11.6	
P	0.17 ± 0.09	29.7 ± 18.3	106.3 ± 35.3	28.1 ± 12.8	

Table 2 : Mean and standard deviation of chemico-physical parameters in karstic (K) and porous (P) aquifers. T = temperature; Cond. = electrical conductivity; O_2 = dissolved oxygen; O_2% = saturation oxygen; PO_4 = total phosphates; NO_3 = nitrates; Ca = calcium; Mg = magnesium.

as in the investigated Lessinian sites. In the 29 karstic sites, stygoxene species were distributed at various depths reaching 240 m. On the contrary, in the 47 porous media, the stygoxenes seemed to be confined to the uppermost layers of the aquifers, occurring frequently at low depths (4-16 m) and sporadically and with low abundances at more consistent depths (23 and 120 m) (Fig. 5).

The observed distribution of stygoxenes in the two aquifer typologies resulted not to be linked to chemico-physical factors, as karstic and porous aquifers showed similar behaviour from this point of view (Table 2). In regard to the 9 priority sites of the network of conservation, neither stygoxene nor stygobiont species seemed to be affected by high concentration of nitrate and/or phosphate or by the oxygen depletion or by other chemical parameters (Table 3).

The t-test for temperature ($t = —1.14$; $p = 0.25$), dissolved oxygen ($t = 1.66$; $p = 0.1$), saturation oxygen ($t = 1.60$; $p = 0.11$), phosphate ($t = —0.8$; $p = 0.42$), nitrate ($t = —0.66$; $p = 0.5$) and calcium concentrations ($t = —1.74$; $p = 0.08$) confirmed that there is no statistically significant difference between these parameter values in karstic and porous aquifers at a α-probability = 0.05. The two aquifers typologies differ only for magnesium concentrations ($t = —3.37$; $p = 0.0011$) and pH ($t = 2.42$; $p = 0.01$).

On the basis of the above observations, the presence of stygoxenes in the 9 saturated sites is likely to be indicative of the presence of hydrological connections between groundwater and surface water. More in particular, the presence of stygoxenes in deep, oligotrophic groundwater environment is to be viewed as the result of a fast passive transport operated by infiltrating surface water. As far as the Crustacea Copepoda are concerned, the passive displacement is facilitated by the presence of larval stages (nauplia and copepodids), prone to be transported. Consequently, the occurrence of epigean copepods in deep aquifers may be frequently interpreted as a result of hydro-transport (Rouch, 1980). By the way, stygoxenes may play the role of Active Exchange Describers (A.E.D.), that is indicators of hydraulic exchange zones (surface water vs. groundwater), which represent also the main infiltration pathways for pollutants (Lafont *et al.*, 1992). The presence of stygoxenes in shallow aquifers (both karstic and porous) of the Lessinian area was somewhat expected, due to the physical closeness of these aquifers to the surface. On the contrary, the collection of alive stygoxenes in deep,

Site	Sx	Sp	Sb	T	Cond.	O_2	O_2	pH	PO_4	NO_3	Ca	Mg
				C°	mS/cm	mg/l	%		mg/l	mg/l	mg/l	mg/l
P20a	0	0	260	14.9	0.890	5.4	53.8	6.8	0.12	56.8	88.1	38.8
P6s	0	0	33	13.6	0.710	7.0	73.8	6.8	0.45	37.4	70.1	20.6
K14a	2	1	121	15.5	0.660	2.9	31.5	8.1	0.17	10.1	44.1	29.1
P9s	0	0	77	16.1	0.730	5.9	61.0	6.7	0.05	15.8	60.1	38.8
K13p	3	0	4	12.3	0.520	6.2	64.7	7.5	0.05	13.2	52.1	7.2
K16a	37	0	143	15.4	0.480	4.5	44.8	7.3	0.04	11.4	48.1	29.1
P10p	0	1	15	13.9	0.460	7.4	73.2	7.8	0.03	13.6	60.1	12.0
P4s	7	0	12	16.1	0.730	5.9	61.0	6.7	0.05	15.8	60.1	38.8
K25a	0	0	1	14.9	0.820	6.5	69.7	7.0	0.20	49.5	100.2	26.4

Table 3 : Abundances of Sx (stygoxene), Sp (stygophile), Sb (stygobiont) copepods and chemico-physical parameters of the 9 priority sites forming the network for conservation (T = temperature; Cond = electrical conductivity; O_2 = dissolved oxygen; O_2% = saturation oxygen; PO_4 = total phosphates; NO_3 = nitrate; Ca = calcium; Mg = magnesium).

	P6s	P9p	K13p
I.V.m	3	4	1
Sx	no	no	yes
I.V. i	3	4	2

Table 4 : I.V. (Intrinsic Vulnerability) of the selected priority sites (I.V.m = I.V. from the hydrogeological map; Sx = presence of stygoxenes; I.V.i = implemented I.V. values).

oligotrophic aquifers (both porous and karstic ones) was taken as a warning of intrinsic vulnerability as already pointed out by Malard *et al.* (1994, 1998).

As a result of this, an eco-hydrogeological approach, which combines the Sx-presence and hydrogeological data for the assessment of aquifer intrinsic vulnerability, was applied. The I.V. values given by the I.V. hydrogeological map were increased of one unit if stygoxene copepods were collected in the priority site under consideration. The I.V. from the hydrogeological map was already classified into 5 classes: 1 (low); 2 (medium); 3 (high); 4 (very high); 5 (elevated). The I.V. values derived by the eco-hydrological approach were therefore rescaled from 1 to 6: 1 (low); 2 (medium); 3 (high); 4 (very high); 5 (elevated); 6 (very elevated). With regards to K13p site (3 Sx vs. 4 Sb), the Sx-correction factor increased the I.V. from 1 to 2. In Table 4 the I.V. values of P6s, P9p and K13p are reported.

3.6 Computation of the risk

The risk faced by an aquifer depends primarily on its natural defences rather than on the intensity and type of the pollution source. According to this, the risk to which the priority sites are exposed was computed as the product of three factors: Intrinsic Vulnerability (I.V.), Probability of occurrence of the potential negative impacts (P) and intensity of the impact Damage (D). In this approach the impact Damage (D) is supposed to be a parameter which can assume only two values: 1 (low damage) and 3 (high damage). The damage intensity was defined on the basis of the degree of alteration experienced by groundwater communities/habitats after the impact. Eco-toxicological tests demonstrated that heavy metals, chloride and some pesticides seriously affect the survival of stygotaxa (among others, Mathews *et al.*, 1977; Bosnak and Morgan, 1981a, b; Mösslacher and Notenboom 1999). On the other hand, the lowering of the water-table, due to an over-exploitation, may produce reduction in both habitat dimension and heterogeneity with the consequent disturbance of the communities. Rouch (1980, 1986) observed that the recovery of karstic communities after an over-exploitation is slow but no more detailed information is available on this topic. Similarly, clear evidences about the effect of nitrates and sulphurous oxides on stygo-communities did not receive the necessary attention. In regard to the study area, high concentrations of nitrates (as observed in P20a where [NO_3] = 56.8 mg/l) definitely did not affect the presence of stygobionts while it was observed that very low concentrations of heavy metals (few mg/l) have a strong effect on stygobiont species survival (Mösslacher and Notenboom (1999) for a review). According to this, D values were assigned on the basis of the amount and reliability of data from literature. Moreover, D of demonstrated alteration effects should be a multiple of the value assigned to the supposed ones. The values proposed herein are D = 1 for the damages derived from nitrate leaching, sewage leakage and oil seeping, and a higher value (D = 3) for the damage caused by pesticides leaching. In the Lessinian area, the over-exploitation of the groundwater resources occurs from July to September during the vegetative period of the crops; in the other months the wells are not utilised and the resource has the time to recover. For this reason, D = 1 was assigned to water exploitation, as well (Table 5).

	D
Water exploitation (agriculture)	1
Nitrates leaching (agriculture)	1
Pesticides leaching (agriculture)	3
Sewage leakage (urbanisation)	1
Motorways oil seeping (urbanisation)	1

Table 5 : D (damage intensity) of the selected risk drivers.

The Risk (R) a site experiences was computed by the arithmetic average of the partial risks (D x P x I.V.) multiplied to a factor 10 to avoid decimals. In the Lessinian area R ranges from 0 to 84. Three levels of risk were selected dividing the risk range in three equivalent classes of values: low (0-28); moderate (29-56) and high (57-84). The risk values for the selected priority sites are the following :

P6s: R = {[(1x1x3)+(1x1x3)+(3x1x3)+(1x0.5x3)+(1x1x3)]/5}x10 = 39

P9p: R = {[(1x1x4)+(1x1x4)+(3x1x4)+(1x0x4)+(1x1x4)]/5}x10 = 48

K13p: R = {[(1x1x2)+(1x1x2)+(3x1x2)+(1x0x2)+(1x0.5x2)]/5}x10 = 22

which correspond respectively to moderate (P6s and P9p) and low (K13p) levels of risk.

3.7 Proposal of signposts for sustainability

The conservation actions a site requires were estimated on the basis of the risk it faces. The purpose at the basis of the approach is to suggest conservation actions which are sustainable in the Lessinian area which is low-industrialized and low-densely populated. According to this, feasible and low-cost management procedures were suggested for the moderate-risked sites (P6s and P9p), while conservative actions were proposed for the low-risked aquifer (K13p). Into the R.R.Z. of the porous sites and in the recharge area of the karstic one, some interdictions are recommended, such as on gravel extraction, dumps and mine openings (Sket, 1999). More in particular, the utilization of more efficient irrigation techniques, such as drip irrigation, is suggested in the R.R.Z. of P9p, in order to reduce the water loss with the consequent decreasing of the water-table. Furthermore, P9p is located very close to Pantena stream (indicated by the white thick arrow in Fig. 4) so that it would be possible to utilize also stream water for irrigation; however, because of the low discharge of the stream, this practice should be pursued only in the first weeks of the vegetative period when the water need of the crops is low. The priority site P6s is located downstream the urbanised area of Montorio (Verona Province) and its R.R.Z. includes part of the urban agglomerate. The conservation measures for this site should foresee the sewage pipes maintenance in order to avoid the leakage of contaminants. The recharge area of K13p is interested by agriculture and small manures, however, the nitrate and phosphate concentrations are low and the groundwater is enough oxygenated (Tab. 3). As a result of this, the present management of the area is thought not to affect the groundwater biota and therefore the strategy proposed is conservative.

4. CONCLUSION

One of the main purposes of the European and Italian water policies is the pursuing of the sustainable use of the water resources (2000/60/EC; D.Lgs. 152/99). Similarly, it is also stated that the status of aquatic ecosystems (including surface waters, costal waters and groundwaters) has to be enhanced and preserved from further deterioration (2000/60/EC, art. 1) through management practices which guarantee the water bodies to support wide and well diversified faunistic and floristic communities (D.lgs 152/99, art. 1). On the other hand, in both normatives, neither the ecological status of groundwater nor the importance of groundwater biota as indicators of groundwater status have been yet recognised. As a matter of fact, although the knowledge about the groundwater ecosystem has greatly increased in the last years, the dissemination of information about groundwater biota and ecosystems is still scarce. Particularly in Italy, these topics rarely overcome the boundaries of the scientific academic world which should face the challenge of widespreading information. The approach here proposed applies to the Italian context the procedure developed by De Broyer *et al.* (2004) within the framework of the PASCALIS (2002) project. The procedure was focused on the paradigm of sustainability for groundwater through the endorsement of the biota conservation in the use of the resources. The aim of the approach was to preserve groundwater species through the conservation of their natural habitats. An index of conservation values (C.V.) for stygobiont species (Stoch *et al.*, 2004) was utilised in order to identify a network of groundwater sites priority from a biological point of view. According to the economic context of the Lessinian area, some management actions were proposed with the aim to avoid further groundwater habitat reductions and contaminations. The proposed conservation procedures were applied to limited areas such as R.R.Z. (Restricted Respect Zones) and recharge areas around the priority sites in order to spare revisions of regional planning in terms of soil uses and management practices. The use of A.E.D. (Active Exchange Describers) in the assessment of the intrinsic vulnerability of aquifers was usefully proposed in this approach. On the other hand, the procedure requires further standardization. As a matter of fact, the list of risk drivers is far from being complete and some other drivers, occurring in other areas (e.g., salt water infiltration), should be included. Accordingly to this, the risk range is subjected to further revision. Hence, the proposed procedure, which fitted to the Lessinian sites, is in need of validation and adjustments in order to be usefully applied at national and European level.

ACKNOWLEDGEMENTS

This work was financially supported by the European research project PASCALIS : **P**rotocols for the **AS**sessment and **C**onservation of **A**quatic **L**ife **I**n the **S**ubsurface, (contract no EVK2-CT-2001-00121) of the Fifth Research and Technological Development Framework Program of the European Community.

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