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Extended Abstracts

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Conceptual frame of the safeguard zones**

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ABSTRACT

Groundwater is a basic source of supply for populations and for other activities related to the human development. For this, it is necessary to establish suitable protection measures in order to achieve the good status of groundwater bodies intended for human supply according to the requirements of the Water Framework Directive (WFD).

In this work a conceptual frame is defined for the delimiting safeguard zones in the groundwater bodies destined to human consumption according to the requirements of the WFD. It is necessary to create a methodology that considers the distribution of water body abstraction points, hydrogeological criteria, evaluation of pressures and vulnerability, also considering the wellhead protection areas of abstraction points among others. The processing and analysis of these data by means of a Geographical Information System (GIS) will allow the establishment of safeguard zones in groundwater bodies.

As a general protection measure, the first advances, in Spain, in the development of a methodology to delimit safeguard zones are presented here.

INTRODUCTION

The protection of water has become one of the high-priority environmental objectives in the European Policies with the entry into force in the year 2000 of the Water Framework Directive (WFD), Directive 2000/60/EC of the European Parliament and of the Council (European Union, 2000), and the Directive 2006/118/EC of the European Parliament and of the Council, in the year 2006 (European Union, 2006), regarding the protection of groundwater against pollution and deterioration. Groundwater constitutes a basic resource in Europe which is demonstrated in countries such as Austria, Germany, Italy or Denmark where more than 70% of the population's water supply comes from groundwater (Martinez Navarrete et al., 2008).

The need to make the socioeconomic activity compatible with the safeguard of the groundwater quality has been approached historically by means of the zoning of the territory made by the characterization of the environment. Since protection strategies have delimited wellhead protection areas (source) and the intrinsic vulnerability has been evaluated to the pollution of the aquifers to protect the resource. These figures of protection are of great utility but they must be combined with other factors to provide to the groundwater bodies of a suitable protection.

In this work a conceptual frame is defined for the delimiting safeguard zones in the groundwater bodies destined to human consumption according to the requirements of the WFD. This figure of protection is equivalent to "wellhead protection areas" of the groundwater bodies destined for the human consumption according to the article 7.3 of the WFD.

Once the propose zoning is made, it is necessary to analyze and to integrate these protection areas in the different policies with incident in the land management. Therefore it should be accompanied by a guide of recommendations and restrictions in relation to installation of new human activities, conditionings to subject to pressures or location of new captations for supply.

SAFEGUARD ZONES AS A MEASURE OF PROTECTION

The "safeguard zones" are areas (that can be established optionally as stated in the WFD) whose scope focuses on measures to protect groundwater with the aim of avoiding the deterioration of

water quality and reducing the level of purification treatments required for human water consumption. This is a highly recommendable option as it has been extensively used for the delimitation of numerous water bodies in several Member States.

They are therefore equivalent to “wellhead protection areas” of groundwater bodies intended for human consumption according to article 7.3 of the WFD. The size of the “safeguard zones” can be highly variable; in many cases they will be smaller than the groundwater body and several “safeguard zones” can coexist in the same water body as well as extend outside of it, which for example occurs with karst materials due to their characteristics and the location of their recharge zones. On the other hand, “safeguard zones” can correspond to the entire extension of a groundwater body or surround the wellhead protection areas of existing abstraction points (Figure 1) (Jiménez Madrid et al., 2008).

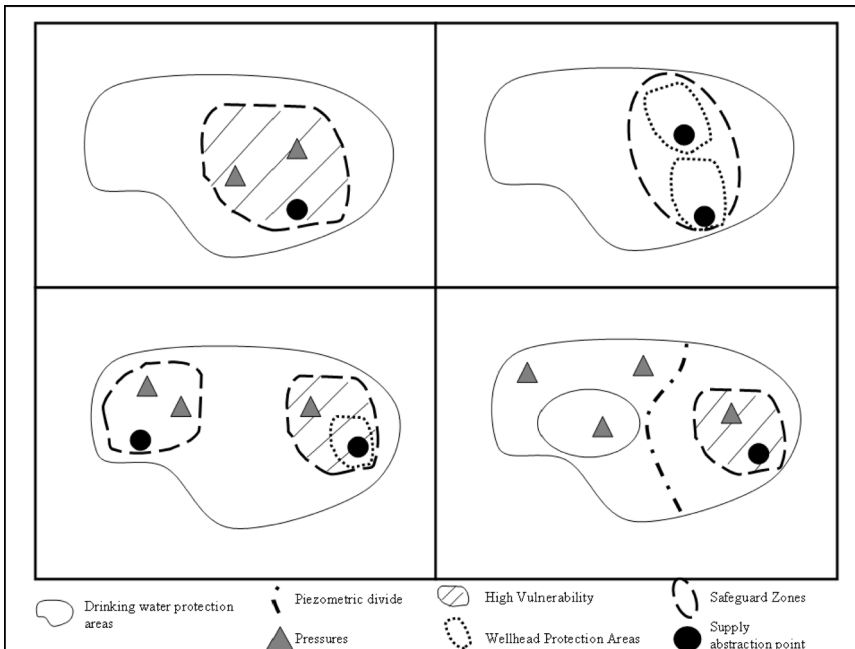


Figure 1. Possible configurations of safeguard zones.

In order to be able to apply these considerations to a large number of groundwater bodies, as is the case in Spain, it is advisable to use a methodology that specifically considers the contamination risk when delimiting safeguard zones. (Jimenez Madrid et al., 2008, 2010). To achieve a global protection, priority measures should be considered as follows:

- Water supply abstraction points: The location and characteristics of groundwater abstractions intended for human consumption are analysed (according to the requirements of the WFD: > 0.1 L/s or serves 50 persons).
- Previously established wellhead protection areas for abstraction points intended for water supply.
- Established wellhead protection areas for mineral waters.

- Information referring to purification treatments (as a reference point to prevent its possible contamination resulting from pressures).
- Intrinsic vulnerability of groundwater bodies to contamination.
- Pressures on groundwater bodies and risk evaluation.
- Definition of aquifer recharge zone boundaries.
- Establishment of monitoring networks in protected areas, by selecting representative abstraction points intended for human consumption, to verify the fulfilment of article 7.3 of the WFD.
- Groundwater body piezometric levels and flow directions.
- Effects of seawater intrusion.

The analysis of each of these parameters and their joint assessment through GIS tools will allow the establishment of a conceptual framework for the development of a methodology to delimit safeguard zone boundary lines as a global protection measure of groundwater bodies intended for human consumption.

Once the proposal of safeguard zone boundaries has been defined, it is necessary to draft a recommendations and restrictions guide in relation to the introduction of new activities, conditioning factors of existing pressures or location of new abstraction points. In order for the protection measures to have a positive effect, they should be included in the urban regulations and other regional policies affecting the land use.

FIRST ADVANCES IN SPAIN

In order to define safeguard zones in all groundwater bodies used for human consumption, a collaboration project is being carried out in Spain between the Ministry of the Environment and Rural and Marine Affairs and the Geologic Survey of Spain. Preliminary results contemplate four possible zones in groundwater bodies:

- A. Safeguard zone with heavy restrictions
- B. Safeguard zone of future prevention
- C. Safeguard zones not established
- D. Safeguard zone with moderate restrictions

The zones to be established will be defined in different phases with an increasing degree of complexity and precision in the work required. In this work we present the preliminary results obtained after the application of the first phase of work. In the First Phase (Table 1) each groundwater body used for human consumption will be analysed in its whole extension, to identify which of the 4 zones proposed (A, B, C, D) can be distinguished in them, according to the vulnerability pressures analysis.

For the vulnerability analysis of groundwater bodies crossing territorial boundaries within Spain, the COP method (Vías et al. 2006) has been used for carbonate aquifers and the reduced DRASTIC index (DGOHCA and IGME, 2002) for intergranular porosity aquifers. These obtained vulnerability classes have been sorted into in two groups (Table 1).

Table 1. Criteria for the delimitation of safeguard zones in Spain (First Phase).

CRITERIA FOR THE DELIMITATION OF SAFEGUARD ZONES			
VULNERABILITY (V)		PRESSURES (P)	
Group	Score	Group	Score
COP: Range between 0-1 = HIGH	2	Existence of pressures in the scope of the groundwater body	4
COP: Range between 1-15 = LOW	1		
Reduced DRASTIC: Range between 72-156= HIGH	2	Nonexistence of pressures in the scope of the groundwater body	2
Reduced DRASTIC: Range between 16-72 = LOW	1		

Zone A (V + P = 6): High vulnerability and significant pressures.
 Zone B (V + P = 5): High vulnerability and insignificant pressures.
 Zone C (V + P = 4): Reduced vulnerability and insignificant pressures.
 Zone D (V + P = 3): Reduced vulnerability and significant pressures.

Existing pressures in each groundwater body have also been evaluated obtaining a layer in which they are all projected and overlaid according to the criterion set out in Table 1. Finally, using GIS tools, the joint analysis of both factors was carried out by adding the scores given to the vulnerability and pressures and thus cataloguing the entire extension of the groundwater body.

RESULTS

Figure 2 show the first results obtained in the Intercommunal Basins of Spain inside the project carried out in Spain between the Ministry of the Environment and Rural and Marine Affairs and the Geologic Survey of Spain.

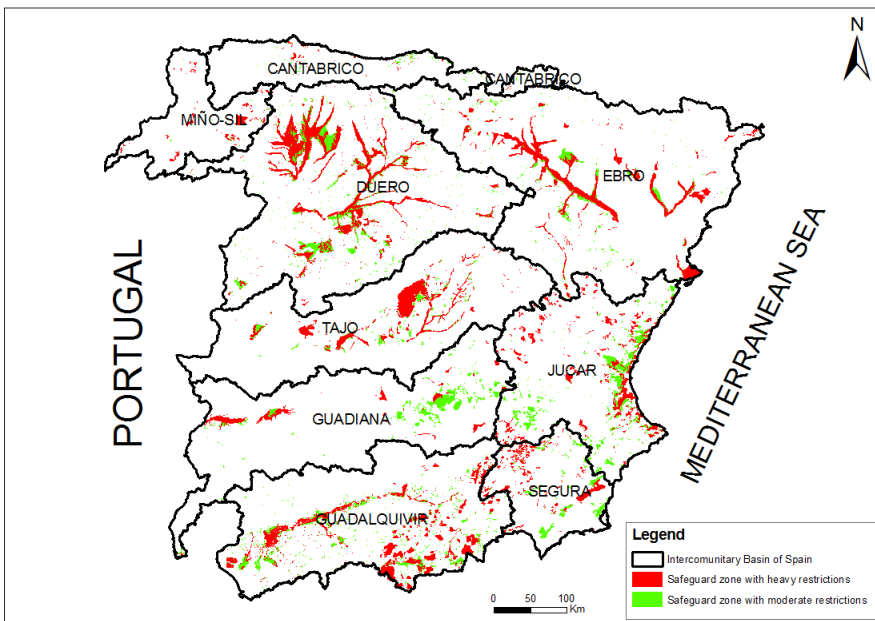


Figure 2. First results in intercommunal river basins of Spain.

The safeguard zone type A occupy on 5% of the surface in all the Basins except in the Guadalquivir and Segura Basins where they spread for over more than 10 % of the territory (Table 2).

Table 2. % occupation of the territory of the safeguard zones type A in the different Basins.

BASIN	% OCCUPATION
DUERO	5,75 %
TAJO	2,49 %
MIÑO-SIL	1,54 %
SEGURA	10,21 %
JÚCAR	5,21 %
EBRO	5,75 %
GUADIANA	2,49 %
CANTÁBRICO	1,54 %
GUADALQUIVIR	10,21 %

CONCLUSIONS

The protection of groundwater used for human consumption is one of the high-priority environmental objectives of the Water Framework Directive. The establishment of safeguard zones as a global measure of protection for groundwater bodies intended for human consumption is an advisable option to comply with the requisites imposed by the WFD.

An initial methodological approach has been developed for the delimitation of safeguard areas which is divided in several working phases. In this work, we present the preliminary results obtained after the application of the first phase of work. In the first phase the evaluation of intrinsic vulnerability to contamination and the existence of pressures are considered.

Once the proposal of safeguard zone boundaries has been defined, it is necessary to elaborate a recommendations and restrictions guide and they should to be included in the urban regulations and other regional policies affecting the land use.

In future phases of works it will be necessary to contemplate other factors that allow the characterisation of safeguard zones of groundwaters used for human consumption with more accuracy.

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