Role of public awareness in groundwater protection

M. Ekmekçi · G. Günay

Abstract Scarcity of water, particularly in towns situated along the Mediterranean coast where the main aquifers are in karstic carbonate rocks, necessitates more thoroughness in exploiting and protecting the groundwater resources. Geomorphological and hydrogeological studies have revealed large quantities of the input and throughput features, such as sinkholes, dolines, uvalas and poljes in the recharge areas of many karst aquifers in Turkey. Naturally, recharge areas are generally located at higher elevations and regions remote from the urbanized areas. These features lead the local authorities and persons to utilize the karst features for their own purposes. Dolines and ponors are commonly utilized as injection points for wastewater, while uvalas and poljes are used as solid waste disposal sites. When doing this, the people are unconscious of the connection of such sites with the wells or springs that provide water for their supply. A number of occurrences in Turkey have demonstrated that, no matter how perfect the efficiency of the technical work, protection of the water resources is primarily related to the consciousness of the local authorities. They must either take proper measures to protect the resources or to educate the public in this issue. To achieve this aim, it is very important to involve the public administrative sector and the technical sector in preparing guidelines for integrated environmental evaluation of karst water resources. The main phase of a study should include locating appropriate sites for disposal of wastewater and various liquid and solid wastes that will satisfy requirements by the administrators as well as providing a water supply of good quality for the public. This paper discusses the issue of how to overcome the public awareness problem. Some examples demonstrate how the technical achievements failed to be effective and applicable due to the lack of contribution on the part of the local authorities and the public. Some suggestions are made concerning a revision of the currently insufficient regulations.

Key words Groundwater pollution · Protection zones · Public awareness · Administration · Law and regulations · Turkey

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M. Ekmekçi (✉) · G. Günay
International Research and Application Center For Karst Water Resources, Hacettepe University, Beytepe, 06532 Ankara, Turkey

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Introduction

Survival of a science as a profession is closely related to the effectiveness of its practice in the everyday life of the society. Lack of adequate scientific concepts and lack of public awareness which has great influence on the implementation of projects, are the two major sources of inadequacy in effectiveness of karst hydrogeological practices. The first is not the concern of this paper. However, a brief discussion of the problems faced in producing high-quality studies is necessary for the completeness of this study. The second seems to be even more important because it indicates that, even if a high-quality study is performed, it most probably fails to be effectively implemented if the public who benefits from it are not aware of the reason for carrying out the project. Lack of effective laws and regulations concerning protection of water resources in karst terrain also contributes to the lack of appropriate implementation of the submitted projects. Given the complexity of karst and its high susceptibility to pollution of karst water resources, it becomes ever more important to urge the legislative authorities and decision-makers to pay increasingly more attention to the protection of these resources. It will be too late 5 or 10 years from now when we lose our huge karst water resources, not in quantity but in quality, because rehabilitation is always much more expensive and time-consuming than protection and maintenance.

Problems due to deficiencies in scientific concepts

There is a large technical community that provides hydrogeologic information and services to the general public. In Turkey, this community is mainly formed by those whose background is geology, civil engineering and agricultural engineering, and who have no education in hydrogeology. From the 1960s to first half of 1970s, the study of hydrogeology installed itself as a field of the earth sciences, and therefore mainly geologists have been involved in projects concerning water resources research, development and management. However, the need for earth scientists specialized in water resources, particularly in karstic terrains, is apparent in view of the fact that some major projects such as the Keban and Apa Dams have failed to function properly due to the lack of knowledge of karst.

Aiming to meet this need, the Hydrogeological Engineering Department was established at Hacettepe University in Ankara in 1977. Within the framework of a joint project with United Nations Development Programme (UNDP) in 1984, the International Research and Application Center For Karst Water Resources (UKAM) in Ankara set the immediate objectives of establishing hydrogeological laboratories for education and research, training engineers and technicians who are concerned with water resources projects, and of supporting government agencies in solving problems related to water resources.

UKAM started conducting research and application projects related to karst water resources at home and abroad.

Apart from the objectives foreseen in this project, the Hydrogeological Engineering Department and UKAM especially focused their activities on how to increase the ability to produce high-quality studies.

The following are among the factors that have been considered in the research and education program of the department:

- provision of adequate academic preparation
- experience in the application of investigative and analytical techniques
- imposition of motivation or incentive to do the best work
- provision of competent and timely supervision
- promotion of the use of scientific concepts rather than subjective judgment.

All these objectives are useful in producing well-educated and experienced individuals in karst hydrogeology to meet the employment demands. However, several cases experienced in Turkey have shown that this is not sufficient for effectively implementing a project. That is, if the task of well-prepared technical individuals is only to submit reports on alternatives of a project, they have almost no influence on decision-making or control during implementation. Decision-makers, usually governors, mayors and other local administrators, normally lack the basic technical knowledge that is certainly required during decision-making and control of a project. Politics and other expectations guide their decisions to a great extent. Technical aspects are generally ignored in this process due to the lack of knowledge required for an effective evaluation of the submitted reports. The effects of considering one of these aspects as of high priority and dominant over the others are depicted in Fig. 1. The most efficient application is shown where the administrators and technical personnel work together on the projects.

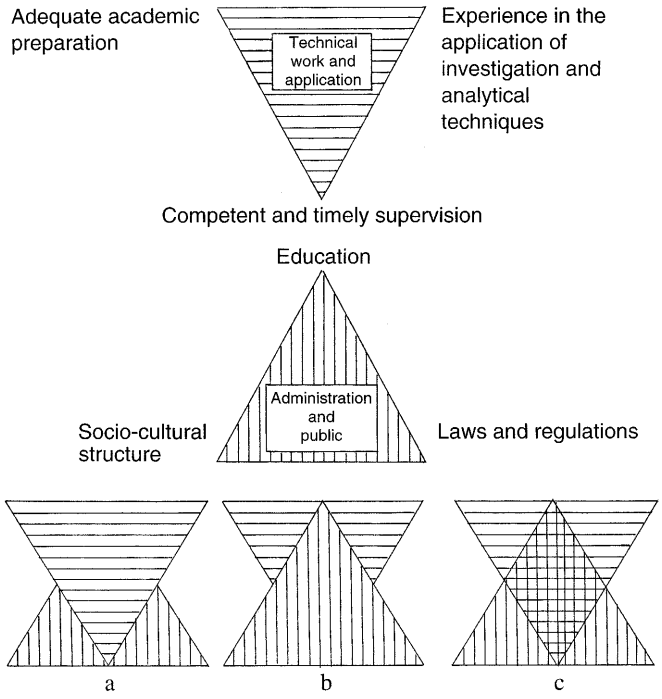


Fig. 1
Effectiveness of measures (technical and administrative) according to their share in the decision-making process: **a** technical works dominant over the others: not sufficiently effective; **b** administrative decision dominant over technical works: not sufficiently effective; **c** administrators and technical personnel enrolled: most efficient application

Educational deficiencies

It is apparent that education and training activities to meet the need for well-educated and experienced hydrogeologists are not the only requirements to be fulfilled with regard to the effectiveness of a project.

Laws and regulations, on the other hand, are again not effective if the required correct interpretation and evaluation are not provided. Besides, laws and regulations established previously are insufficient, particularly as concerns protection of water resources against pollution in karstic terrains. Delineation of protection zones does not consider the very unique behavior of karst in terms of recharge. The subsurface catchment area may not coincide with the topographic drainage area. Karst hydrogeologists know how to approach the complex nature of karst

groundwater flow. Therefore, distance between the recharge area and wells or springs and rapid flow means more to them than it does to those who lack the basic knowledge of karst and pollutant behavior in the subsurface.

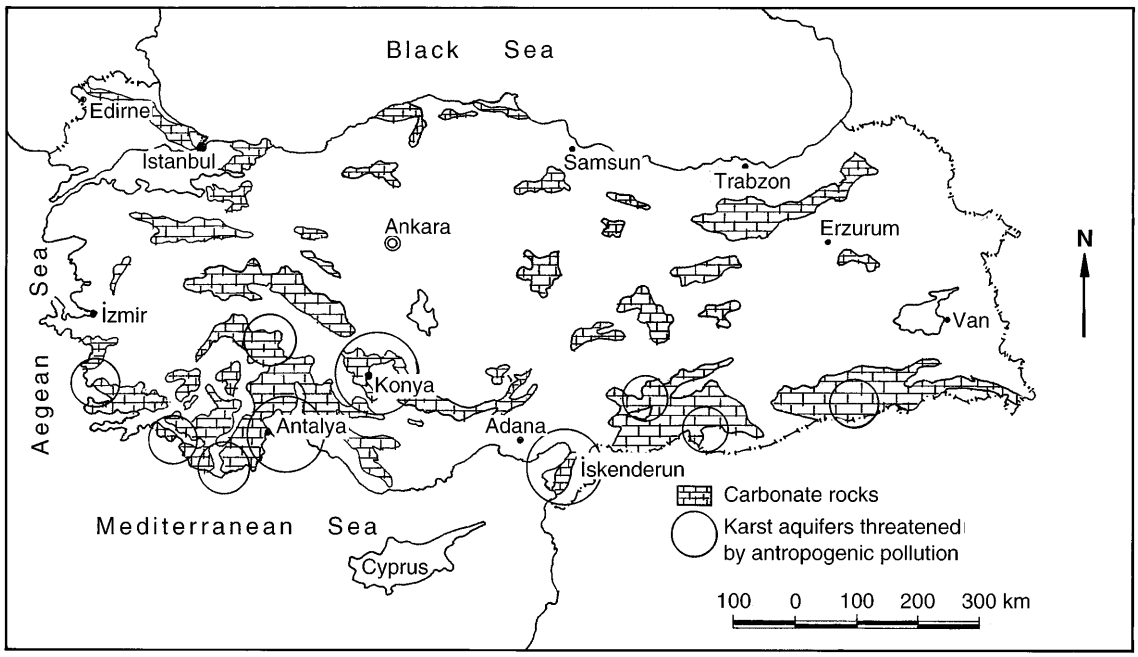
Cases in Turkey

Turkey, with karstifiable rocks extending over about one third of its surface area, exhibits spectacular mature karstic features, especially along the Mediterranean coast. Major cities and towns are found along the coast where topography favors settlement. With coastal plains bordered by high carbonate rock masses having a very steep topography, the two main problems always seem to be present in most of the settlements are water supply and solid and liquid waste disposal. Apparently, these settlements had drawn their water from alluvial aquifers until they experienced contamination by sea water intrusion. This was due to mismanagement of this type of aquifer by disregarding the potential population increase. Abandoning alluvial aquifers, authorities sought new water resources to meet the increasing demand for water by the increasing population. As a consequence, karst springs of relatively large discharge located in remote areas and karst aquifers supplied the water needed in most places. This was, however, only a short-term solution for the water shortage problem in terms of quantity. However, municipalities and other units, such as the army and industrial plants, continued to inject their liquid waste into "some holes that swallow these wastes easily". Being ignorant of the role of karstic features as input controls to the groundwater system, they believed that the location of these sinkholes was far enough from the settlements to do no harm. These types of waste disposal appear to be a common practice in almost every municipality along the Turkish Mediterranean coast (Fig. 2). The city of Antalya is located in an interesting and peculiar travertine area whose surface area is about 630 sq km reaching 250 m of thickness in some places. The travertine is highly porous and forms the second major aquifer in the area. There are several boreholes drilled within the travertine aquifer, supplying water to the municipality. Karst springs such as Arapsuyu and Magara also are utilized to meet the water demand (Fig. 3).

Authorities who were generally uninformed of the importance of swallow holes in the groundwater system had never regarded waste disposal as a problem, and therefore construction of a sewage system had never been supported or even thought of until recently. The decision-makers believed, as did the public, that there was no need for such an expensive construction where you have a ground swallowing whatever you inject; "This is a natural disposal site". UKAM researchers have carried out many studies also concerning groundwater pollution and protection and submitted several reports suggesting a protection strategy for karst aquifers. Authorities, including those of the Ministry of Environment, appeared to be convinced. However, a huge organized industrial complex is presently being constructed in the upstream area on the travertine, again without taking any measures against groundwater pollution.

Moreover, huge tourist hotels without sewage systems were built very close to the springs supplying water to the town. Decision-makers allowed all types of construc-

Fig. 2
Distribution of carbonate rocks and the karst aquifers threatened by anthropogenic pollution



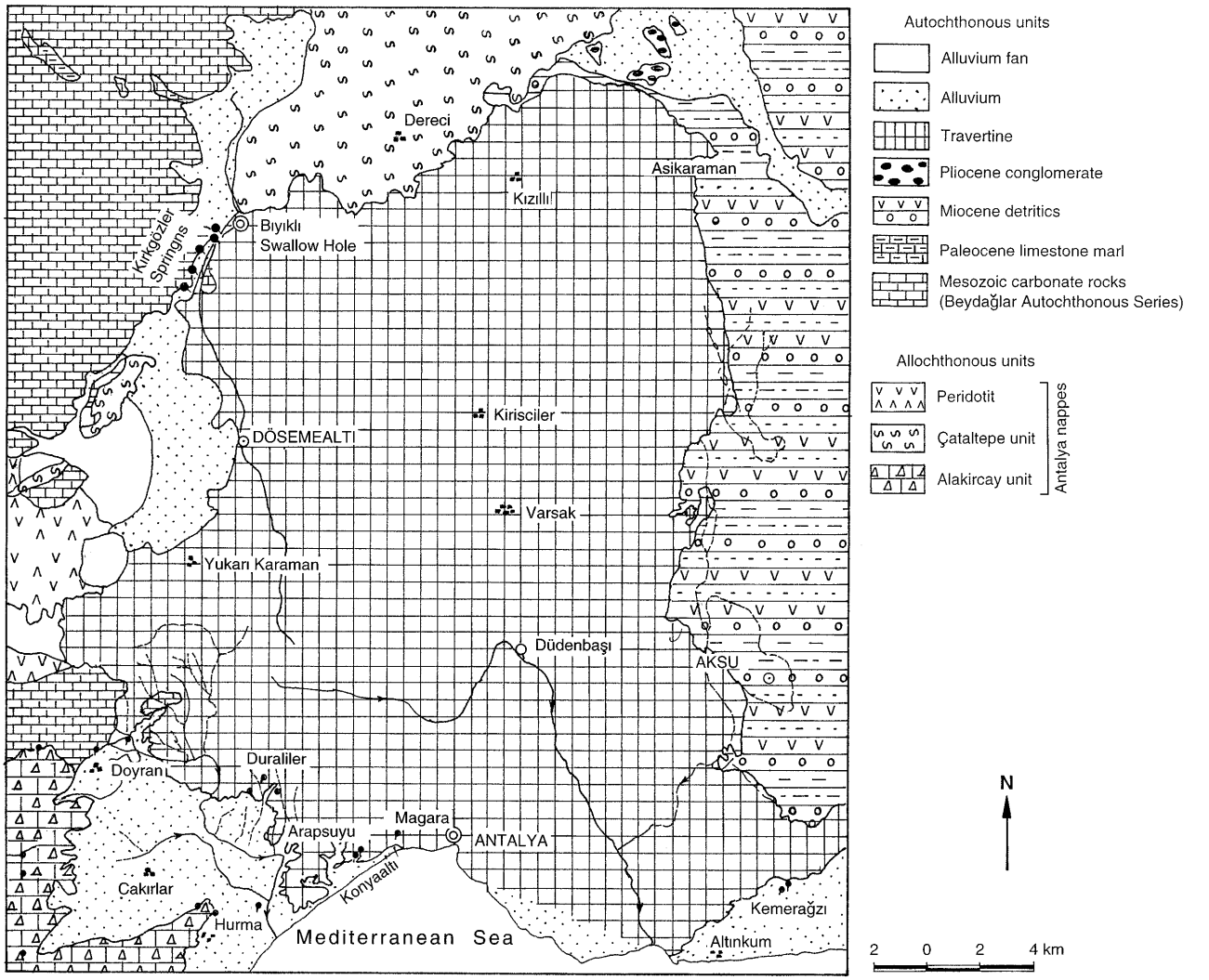


Fig. 3
Hydrogeological map of Antalya Travertine Plateau

tion, even though the law and regulations advise them to take precautions against groundwater pollution. However, these precautions are not clearly defined and therefore generally fall short in groundwater protection, particularly in karstic terrains.

A second example is the city of Iskenderun, in the eastern Mediterranean region in Turkey. There are not only domestic liquid wastes injected into dolines and sinkholes, which are all located within the recharge area of the boreholes and supply water for the town, but also a large polje which is "quite remote" from the town and is being utilized as a solid waste disposal site. The production boreholes are only a few kilometers away from the polje and the sinkholes (Fig. 4). Moreover, they are the only source of water supply.

UKAM again submitted a report on this situation and discussed the problem with the administrative personnel to make them discontinue this practice. They seemed to be quite convinced at the beginning. However, after a few days, it was observed that there was no change in practice. This suggested that technical completion was not effective or adequate as concerns the environmental aspects of karst.

A similar problem has been experienced for years in the Konya closed basin in Central Anatolia. The waters from irrigation drainage are sent to sinkholes developed within the Neogene limestone. The water table in the basin is very shallow, which also accounts for the occurrence of intensive obruks (cenotes) in the basin. Therefore, mixing with the groundwater is quite rapid.

Towns along the karstic Mediterranean coast, such as Kaş, Kalkan, Side, Bodrum, etc., suffer seriously from water shortage and yet very valuable groundwater resources continue to be polluted. Why?

On searching for the answer we came to an important conclusion. First, we reviewed our technical studies to verify whether we were adequate scientifically or not. All investigation methods were applied to the highest accuracy possible.

During some special experiments and tests indicating the direct hydrologic relations between the "swallow holes" and springs or boreholes, local authorities were invited to

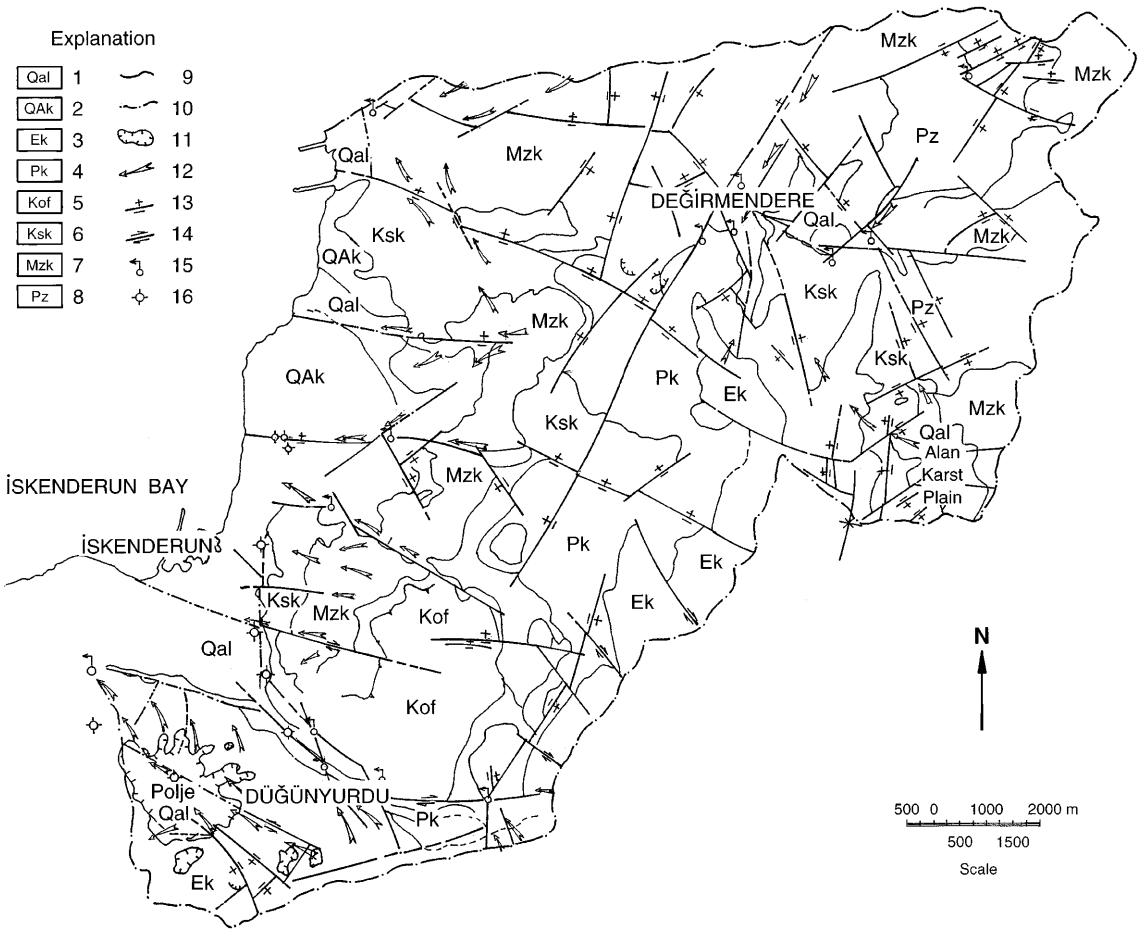


Fig. 4
Hydrogeological map of Iskenderun karst basin. *1* Quaternary alluvium-local aquifer; *2* Quaternary conglomerate-local aquifer; *3* Eocene limestone-upper karstic aquifer; *4* Paleocene sandstone-calcilutite alternation – aquitard; *5* Ophiolithic suit – aquifuge; *6* sedimentary complex – aquiclude; *7* Mesozoic limestone – lower karstic aquifer; *8* Paleozoic quartzite – schist – aquifuge; *9* lithological contact; *10* watershed boundary; *11* karst closed depression; *12* possible groundwater flow direction; *13* normal fault; *14* strike-slip fault; *15* spring; *16* borehole

the field. The reports were submitted personally and detailed explanations given, using everyday language instead of technical language, emphasizing the serious problem that would affect human health in the area. Thus, we decided that the technical side was adequate. *However, the problem is the lack of public awareness. As a matter of fact, people generally tend not to regard an event as a problem unless they personally suffer seriously from it.*

Promoting public awareness

This problem seems to be overcome, to a great extent, by intensive public education, promoting awareness of future health problems, and intensive campaigns via the media. Particularly, regular programs on local television should be broadcast to provoke the people to force the authorities to consider scientific studies and implement technical recommendations. Non-governmental organizations should be informed about these practices, so as to also draw their attention to the threat to human health.
Legal acts and regulations for groundwater protection were established in Turkey in 1967. Since then, there has not been a major revision, neither by a committee composed of non-geologists who have been accidentally involved in groundwater studies, nor by one composed of groundwater specialists who have knowledge of the different aspects of hydrogeology, including karst, which is one of the most important aspects to be considered in such a commission.
The laws and regulations governing groundwater enacted in 1967 do not consider karst at all. UKAM has sent reports with suggestions to the commission, but none of them were considered, again, due to the lack of experience of the members of the commission as concerns karst. According to the current laws and regulations, three protection zones can be delineated on the basis of distance from the water source. However, such protection zones may not be effective in most cases, and even in granular aquifers we should delineate the protection zones on the basis of inorganic and organic pollution.

The behavior of the contaminant in both the unsaturated zone and in the saturated zone should be defined precisely. Because, for inorganic pollution, the concentration of the pollutant is the major factor to be considered in the delineation of the protection areas (Ekmekçi 1993). For organic pollution, determination of filtration velocity and subsequently the 60-day distance is of major importance. Because, a microbial contaminant is assumed to survive not longer than 60-days in a subsurface environment, the protection zone against microbial pollutants is delineated as to allow a travel time for the pollutant not longer than 60 days from the pollution source toward the spring or well.

In karst, description of these factors, subsurface movements of both organic and inorganic pollutants requires specific investigation methods, such as tracing techniques. Therefore, laws and regulations should point to the necessity for determination of protection zones against inorganic and organic pollution separately (Ekmekçi 1993).

Deficiencies in current laws and regulations concerning groundwater in Turkey

The groundwater law enacted in 1967 in Turkey is concerned with exploration and exploitation rights. The term 'rehabilitation' used in this law refers only to rehabilitation of the well itself for the sake of obtaining the largest amount of water possible. It never mentions the quality of water (C.G.E.T. 1981). In 1988, regulations on Water Pollution Control were issued by the Ministry of the Environment. These regulations define the standards rather than describing the measures to be taken against pollution. Regulations mainly deal with controlling the waste effluents in the 'receiving environments' such as rivers, lakes, sea, etc. After classifying the waters based on the quality standards that they define, sampling techniques for pollution examinations are defined in detail (T.E.F. 1992).

Item 22 of the regulations describes the protection zones for groundwater resources as follows:

- groundwater abstraction exceeding the safe yield limit is prohibited in coastal aquifers in order to prevent saltwater intrusion
- all kinds of construction and waste disposal are strictly prohibited in an area within 50 m of the groundwater source (such as spring, well or seepage gallery). An important statement follows: the width of the protection zone can be reduced or increased by the administration, taking into consideration the local conditions. It is quite clear that the administrators may cause a disaster considering the local conditions, whatever they may be in their view. Since the administrator is not familiar with water resources in general in Turkey, local conditions can be evaluated depending on the administrator's subjective judgment at that moment or considering his/her political career. Similarly, other statements are so vague that local authorities (administrator) alone can judge the permissible activities in the protection zone and recharge area of groundwater resources. He or she is not forced to consult with technical people. It completely depends upon his attitude. This makes it more obvious that educating the administrator is of highest priority, since they are the ones who can increase public awareness in groundwater protection issues. A sustainable education can be provided by employing hydrogeologists, at least in municipalities. A very important point is that hydrogeologists must form interdisciplinary groups with a geologist, chemist, biologist and an environmentalist. The groups should be independent from other departments and should belong directly to the decision-making group.

Specifities of karst in relation to groundwater protection and public beliefs

Obviously, no one expects the above laws and regulations to differentiate between karstic or nonkarstic groundwater resources, whereas they are seriously lacking in the technical description of protection zones for all types of water resources. Due to its unique nature, karst requires special knowledge. Besides, the current law and regulations are not even effective for granular aquifers where the groundwater flow is slow and the recharge area mainly coincides with the topographical water divide. In karst, concentrated recharge may often occur through sinkholes, dolines and ponors which are generally located outside of the topographical water divide. The groundwater flow even reaches 800 m/day (Günay unpubl. data, 1981).

People tend to believe that all pollutants are filtered within the ground, and therefore it is quite convenient to inject waste into the ground, particularly in remote areas. Another false belief is that sinkholes and cave shafts are huge conduits swallowing the domestic liquid waste and bringing it to *unreachable great depths of the earth*. This makes administrators reluctant to implement what is recommended by scientists and engineers, because it is more difficult, expensive and time-consuming. They therefore prefer short-term decisions, even though they are wrong in the long run. They feel confident because the adverse effects of such pollution does not become effective immediately. The general attitude is: *it does not exist if it is not to be seen*.

Conclusions

An intensive campaign using media facilities should be organized to increase public awareness in this issue. Short seminars, courses, panels, etc. should be organized to give a general picture of karst to administrators to provide them with the tools they need to communicate

with the specialists. Technical reports to be submitted to local authorities should be discussed orally without using technical terms. Otherwise, after a quick look, all reports will be put on the shelf to be forgotten. Thus, general beliefs and feelings or impressions that are subjective judgement will override the scientific results. People living in and around the area under investigation should be completely informed about what is being done and the reason for it. If possible, they should be drawn into the project in some way, for example, by letting them make known their ideas or beliefs. It would also be of advantage to give brief, simple reports, even to the schoolchildren.

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