Brussels, 7 November 1996

COST 319/96

Memorandum of Understanding

for the implementation of a European Concerted Research Action designated as COST Action 621

"Groundwater management of coastal karstic aquifers"

The Signatories to this Memorandum of Understanding, declaring their common intention to participate in the concerted Action referred to above and described in the Technical Annex to the Memorandum, have reached the following understanding:

1. The Action will be carried out in accordance with the provisions of document COST 400/94 "Rules and Procedures for Implementing COST Actions", the contents of which are fully known to the Signatories.

2. The main objective of the Action is to increase the knowledge necessary to establish criteria for improving groundwater resource utilization in karstic coastal aquifers and for recovering groundwater resource in aquifers over-exploited and salinized due to seawater intrusion.

3. The overall cost of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at ECU 6 million at 1996 prices.

4. The Memorandum of Understanding will take effect on being signed by at least 5 Signatories.

5. The Memorandum of Understanding will remain in force for a period of 5 years, unless the duration of the Action is modified according to the provisions of Chapter 6 of the document referred to in Point 1 above.

GENERAL DESCRIPTION OF THE ACTION

COST 621

Groundwater management of coastal karstic aquifers

A. BACKGROUND

COST Action 65, the mandate of which was completed in 1995 and the main results of which were presented in a special section of the International Symposium and Field Seminar on Karst Waters and Environmental Impacts, held in Antalya in September 1995, brought together a significant number of karst hydrogeology experts. The main target of COST 65 was to establish the right course to be followed in order to safeguard from human pollution the important groundwater resources present in karst aquifers. Within the Action, attention was paid to karstic coastal aquifers as well: it was recognized that groundwater salinization induced by over-exploitation represents a very serious problem, particularly affecting Mediterranean coastal karstic aquifers.

Mediterranean European countries have, in fact, peculiar climatic (low precipitation rate and high evapotranspiration), demographical (increasing immigration and internal migration) and economical characteristics (agricultural practices and tourism which bring about an increasing exploitation of groundwater resources and

high production of pollutants), which determine at the same time water-scarcity conditions, high water-demand and high risk of pollution. Groundwater over-exploitation causes sea water intrusion or determines the involvement of salt waters of marine origin, present inland: progressively, fresh groundwaters turn brackish and become unsuitable for any purpose. Pollution due to human impact very often overlaps the aforesaid salinization.

Karstic coastal areas, in particular, while on the one hand they rely on very good quality groundwater, on the other hand, they suffer from peculiar conditions of water-scarcity due to the lack of alternative surface water resources. They exhibit more serious problems for their management with respect to porous aquifers: the depression due to exploitation of the hydraulic head of karstic channels which bring groundwaters towards the sea, creates an easy way for penetration of present sea water inland, normally resulting in a salinization which advances very fast and affects, in a short time and irregularly, zones very far from the coast.

Due to peculiar hydrogeological environment, no useful methods are available to predict in karstic coastal aquifers the advance of sea water intrusion and its consequences on groundwater quality under over-exploitation conditions. the definition of rules for a correct management of karstic groundwater resources requires great knowledge which can be obtained only through the use of specific methodologies to be still assessed.

A COST Action seems to offer the better perspectives of development and solution, specially when dealing with a topic which involves not only experimental work, but, chiefly, discussion and interpretation of complex features.

B. OBJECTIVES AND BENEFITS

Main object of the Action is to increase the knowledge necessary to establish criteria for improving groundwater resource utilization in karstic coastal aquifers and for recovering groundwater resource in aquifers over-exploited and salinized due to sea water intrusion.

(A) Improvement of knowledge will make it possible to lay down guidelines for the best planning of safeguard and recovering actions of groundwater resources in karstic coastal aquifers and to establish basic criteria to evaluate the salinization hazard connected with exploitation. Guidelines for best utilization of groundwater resources will be based on the concept of integrated management of all available resources, conventional and not conventional, including submarine springs and treated waste water.

(B) Remedial actions practised to recover salinized resources were in most cases very poor and did not produce significant improvement of water quality, notwithstanding the great economical endowments devoted to this purpose: new results should essentially improve the final measures to be adopted.

(C) The adoption by decision-makers of the guidelines should induce clear economical benefits, avoiding dispersion of public funds in ineffective

remedial. A consequent certain benefit of the Action would be to draw the attention of public managers towards the brittleness of coastal karst hydrogeological systems.

(D) another important objective of the Action is to define an international network of investigation Centres and experts of salt water intrusion and related management problems of groundwater resources in karstic coastal aquifers: this network could represent the reference point for Water Authorities in each country.

C. SCIENTIFIC PROGRAMME

The attainment of the objectives of the Action requires the organization and the matching of different disciplines. In the framework of the COST Action this goal should be achieved taking advantage of the different specific qualifications of the researchers involved.

The first step of the Action should be the outline of the state of the art: investigation methods, approach methodologies and management strategies, already tested by the different research teams in their pilot areas, should be carefully examined. The joint examination of the topics, not only on the occasion of periodical meetings and visits, but also through a close exchange among researchers, is absolutely indispensable, because it represents the crucial and significant step of the scientific cooperation. The principal aim of this effort should be to highlight the unresolved subject matter. All researchers are surely aware of

the difficulties inherent in the topic, due to the fact that the number of open problems is larger than that of those resolved. The research themes that will be surely developed are:

(a) Fresh water – salt water equilibrium

The definition of laws which control equilibrium between fresh and salt waters requires some basic data concerning the position and extension of transition zone, the hydraulic heads of fresh groundwater flowing in different karst channels and of underground salt waters. Periodical measurements in observation wells or piezometers penetrating the aquifer at different depths should allow the definition of the relationships between the temporal displacement of transition zone and the variation of fresh water hydraulic heads, connected both to the pumping and the feeding processes. In order to obtain information about the vertical movement of salt and brackish waters, alternative methods, like temperature measurement, geoelectric soundings, magnetic surveys, micro-gravimetry and VLF surveys, etc., should be tested.

Methods suitable to define the communicability between the aquifer and the sea in porous aquifers have to be adapted to karst systems.

(b) Salinization processes in relation to either upconing or lateral intrusion: local and regional flow pathways of intruding sea water

A distinction has to be made between salinization due to involvement of salt groundwaters of ancient intrusion, coming from the deepest part of the

aquifer (upconing) and salinization due to penetration inland of modern sea waters (lateral intrusion): the two processes have a different dynamic development. A useful approach to the problem is through chemical, physical and isotopical methodologies, which can help in outlining differences between old saline water and modern sea water and in reconstructing a scheme of their distribution within the aquifers and of their underground flow pathways, followed from intrusion fronts to the discharge.

(c) Glacio-eustatic oscillations of sea level and water-rock interactions as relevant in permeability variation studies

Presence of salt waters within a karst aquifer originates a series of water-rock interaction processes which can affect the permeability of aquifer: dissolution and re-precipitation of carbonate minerals cause variation of permeability, specially in the mixing zone, where karst processes result newly active. Sea level oscillations in past geological periods determined karstification at various levels of karstic aquifers: the study of this phenomenon is of great importance because the distribution of permeability influences the development of the intrusion itself. Moreover, clay-water interactions can affect permeability, being relevant in determining the clogging of the aquifer, specially during artificial recharge: they have to be carefully known to avoid incorrect planning of remedial actions.

(d) Evaluation of the salinization hazard connected with exploitation

No codified approach exists for the evaluation of the salinization hazard connected with exploitation of groundwater and, consequently, examples of

salinization hazard maps are not available. Hazard is strictly related to both hydrogeological conditions and water requiring human activities; the main difficulty concerns the quantification of drawings and its distribution in the space and in the time. Indirect methods, such as remote sensing for the identification of irrigated areas and statistical analysis of water-requiring activities, should be tested. A serious problem in the evaluation of salinization hazard is to forecast the evolution of the fresh, brackish and salt water circulation in relation to the variation of hydrodynamic conditions due to exploitation. This topic is completely open and useful results are expected from the Action. The results should have an important practical return: the obtained elements should allow the editing of salinization hazard maps, which represent an indispensable tool for decision makers.

(e) Optimization of exploitation and reclaim of salinized karst aquifers

The most important result expected from a correct management plan is the optimization of the exploitation. Most of the work on this topic should be carried out applying mathematical models: the main difficulty which makes critical the modelling of coastal karst aquifers is represented by the definition of hydraulic and hydrodynamic dispersion parameters in karst media. Modelling has to be based on data obtained by monitoring nets: these nets could be well established only on the base of salinization hazard maps. Another result expected by a management plan concerns the remedial actions for the reclaim of salinized karst aquifers. Experiences in this field are numerous, as artificial recharge or hydraulic barrage projects,

but results on karst aquifers have been very poor and normally very expensive. New results are expected from the Action in this field, especially regarding development of new theories and new technologies.

D. ORGANIZATION AND TIMETABLE

The expected development of the proposed Cost Action is summarized in the enclosed diagrams Organization (Encl. 1) and Timetable (Encl. 2). The entire duration of the Action is 5 years: 14 Management Committee meetings are forecast, four of them in Brussels and the others in the participant countries. The meetings will aim essentially at involving everybody in a common discussion about the results of the investigations carried out in pilot areas. Apart from the meetings, a strict connection among the different research teams is expected, through short-term missions and inter-laboratory exchanges.

Two joint-meetings with the members of the COST Action on "Vulnerability and risk mapping for the protection of karst aquifers" are planned.

A Workshop is programmed at the end of Phase III. Experts coming from extra-European countries and representatives of International Associations of World Organizations would be invited, aiming at diffusing to a larger audience the information about on-going Action. Moreover, M.C. would organize a Final Conference. At the Final Conference, scientific and technical results of the Action would be proposed to a full audience, composed of scientists and managers.

During the last year the whole Project will be evaluated by external experts.

During the first Phase, of one year duration, devoted to the outline of the state of the art and the planning of following work, the organization of the entire Action through the set up of 3 Working Groups will be discussed. The Working Group activity is planned to continue till the end of Phase III (Encl. 2). According to the main research lines described in part C, the following arrangement of scientific topics into three main general subjects is proposed:

W.G. I – **Hydrogeology**

Characterization of karstic coastal aquifer structure; Paleo-geographic processes; Karst evaluation; Underground drainage pattern; Hydrodynamic conditions (natural and induced); Water balance; Dynamic of transition zone; Origin and movements of underground salt waters; Hydrodynamic modelling.

W.G. II – **Hydrogeochemistry**

Hydrochemical characterization; Hydrodynamic conditions effecting hydrochemical changes; Water-rock interaction processes in transition zone; Influence of water-rock interaction on hydrodynamic parameters; Other sources of salinization; Water age; Hydrogeochemical modelling

W.G. III – **Exploitation and remedial actions**

Monitoring networks (hydrogeochemical and hydrodynamic); Exploitation methods; Influence on land use changes; Remedial methods; Optimization modelling.

The common result of the activities of the W.G.s will be the preparation of guidelines which, after the fulfilment of W.G. Reports, will be fixed during the IV Phase.

E. Economic dimension

At present, the economical dimension of the New Action has to be estimated on the basis of the participation of the following countries, which, except for Malta, are COST countries:
Croatia, France, Greece, Hungary, Italy, Malta, Portugal, Slovenia, Spain and Turkey.

On the basis of national estimates provided by the representatives of these countries and taking into account the coordination costs to be covered over the COST budget of the European Commission, the overall cost of the activities to be carried out under the Action has been estimated, in 1996 prices, at roughly ECU 6 million.

This amount has been evaluated, as far as national staff costs are concerned, on the basis of a participation of an average number of six persons (scientists and auxiliary personnel) for each research team (in some cases more than one per country) for a mean engagement of two months/year for each person.

This way, the number of person-years expected to be involved in the Action is seventy-five.

This estimate is valid under the assumption that all the countries mentioned above, but no other countries, will participate in the Action.

Any departure from this will change the total cost accordingly.

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