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DISCHARGE CONDITIONS AND VARIATIONS OF THE MAIN HYDROLOGICAL PARAMETERS OF SOME COASTAL APULIAN SPRINGS RELATING TO SEA WATER INFLUENCE OF GROUNDWATER

SUMMARY

With the aim of examining closely the hydrological equilibrium of the aquifer flowing in the Murgia carbonate masses, investigations on the main Murgian coastal subaereal springs located on both Ionian versant and Adriatic one were carried out.

The observations have mostly related to hydraulic features of outflow and the chemical-physical ones of the flowing waters.

Surveys gave the possibility of characterizing springs according to the coastal versant they flow owing to the different hydrological regimen, the different discharge-temperature correlations and saline content values which do not exceed 4 g/1 for Ionian spring waters while for the Adriatic versant ones they can even be of the order of 15 g/1.

In the end, a completely different assumption about present sea waters involving in the saline contamination processes of the aquifer can be pointed out.

1. FOREWORD

With the aim of setting out the relationships between feeding waters and groundwater flows, investigations on the modes by which such underground waters flow to the sea have been started within studies on Apulian ground waters.

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Particularly, in course of studies already conducted on the Murgian aquifer [3, 6, 7] which have fully illustrated the basic hydrogeological features, the main Murgian coastal and subaereal occurrences located on both Adriatic and Ionian versant were considered (Fig. 1).

Such occurrences were kept under observation for about two years with hydrological and hydrochemical surveys.

A precise knowledge about modes accomplishing the aquifer equilibrium accounts for great importance, considering the fact that in this region underground waters represent the only as well as precious source of water supply for irrigation and relatively potable uses.

2. HYDROGEOLOGICAL FEATURES

As it is well known the mesozoic carbonate formation in the Murgia, as well as in the entire Apulian region, stands for an extensive aquifer in which fresh ground waters move.

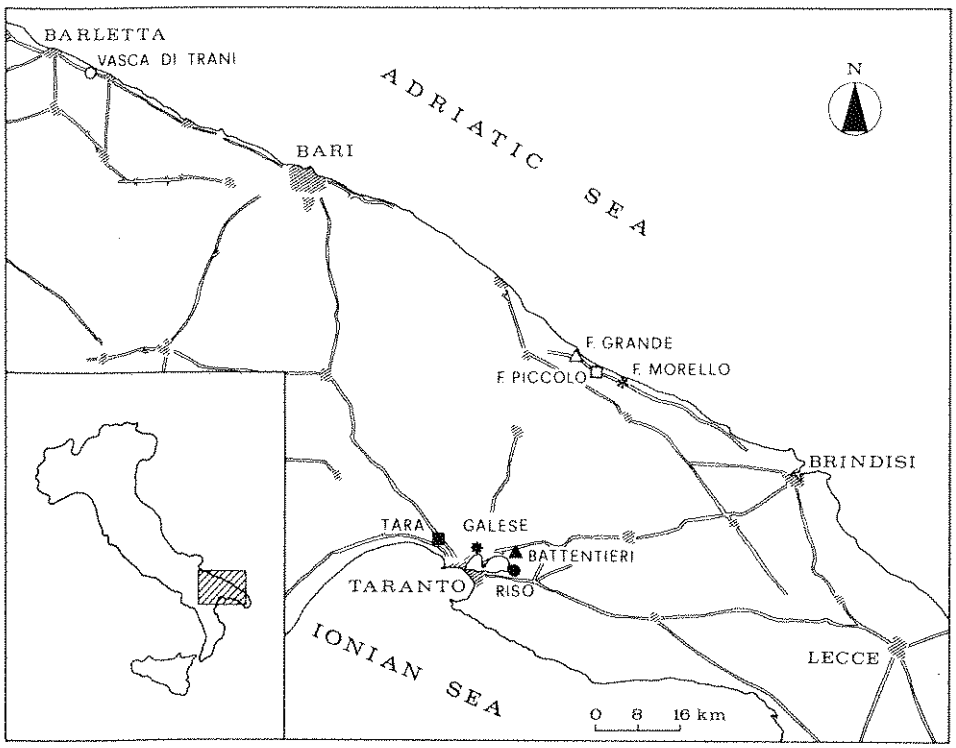

Fig. 1 - Location of the considered springs.

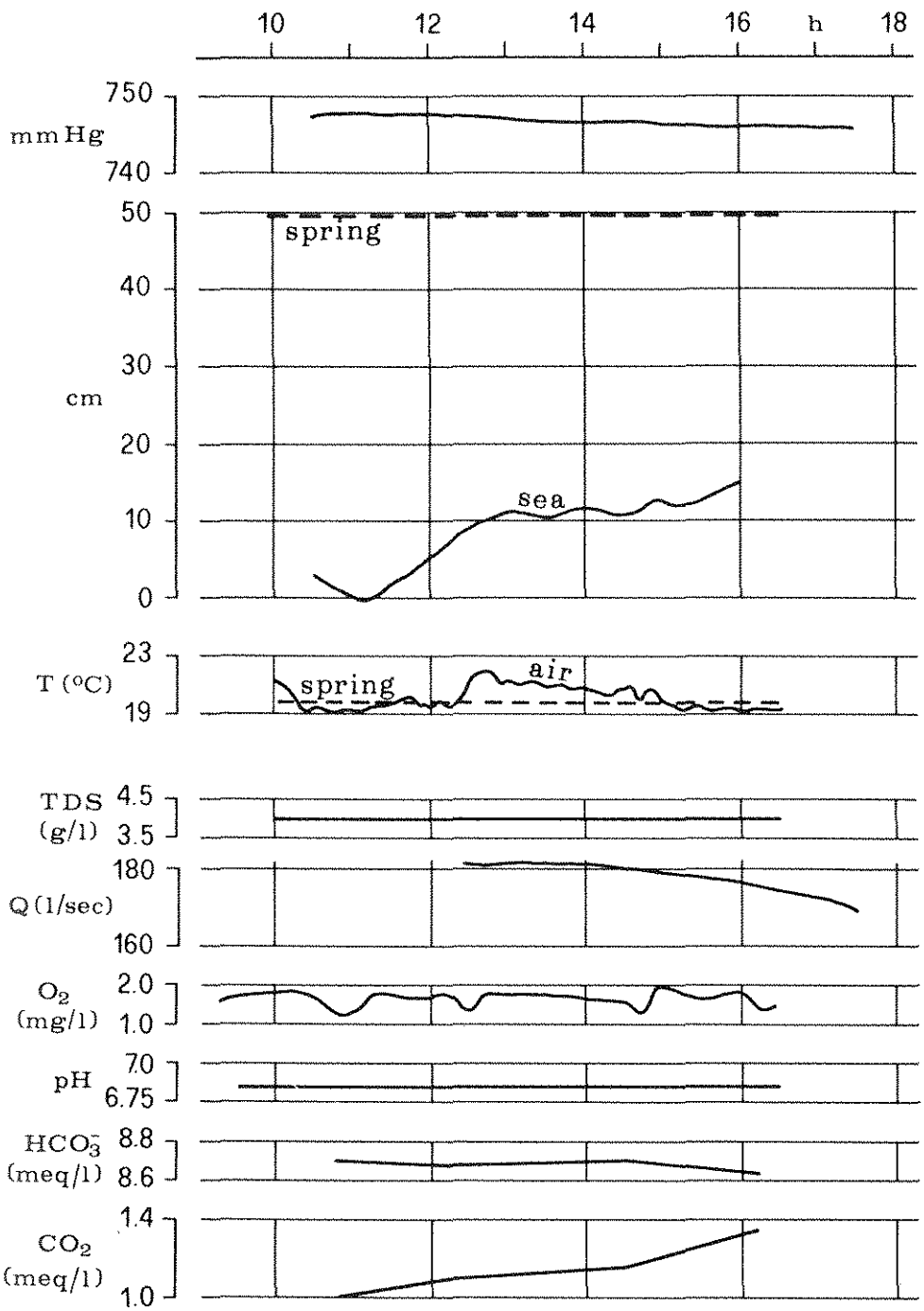

Fig. 2 – Daily surveys of hydraulic, physic and chemical parameters carried out in Vasca di Trani spring's waters dating the 15th of October 1980.

These last are fed by rainwater falling during the autumn and winter period.

The aquifer reaches its hydrological equilibrium by means of a great deal of coastal, subaereal and subaqueous springs which flow into the sea, being this the base level of the aquifer itself.

Generally the groundwaters flow into the sea through draining fronts or in concentrated form according to the fissuration and karst-state in the rocky formation.

The characteristic of mesozoic rocks in the Murgian aquifer is given by relatively scanty permeability owing to a low degree of the karst-state and a

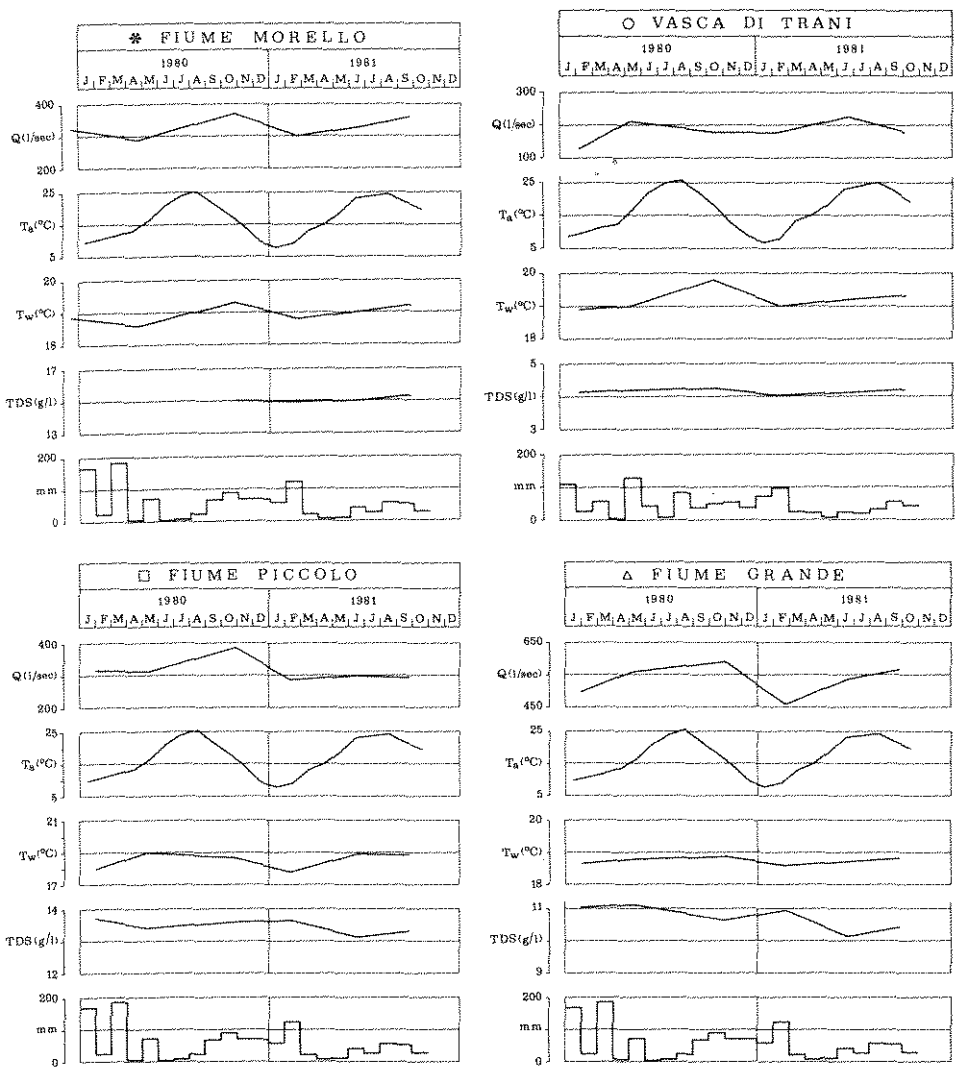

Fig. 3 – Chronological diagrams of discharge (Q), temperature and salinity of waters (Tw and TDS), of air temperature (Ta) and histograms of rainfalls relative to the Adriatic versant's springs.

reduced fracturation developing both vertically and horizontally but markedly anisotropic.

A further characteristic of Murgian region is the almost total absence of draining fronts and the limited presence of subaereal occurrences discharging into the sea, in concentrated form, fresh groundwater with relatively modest flows.

It is obvious, then, that the aquifer hydrological equilibrium in the considered area must be accomplished by discharging such waters into the sea through a series of subaqueous occurrences only few well known such as the «citri» ones in the Mar Piccolo of Taranto.

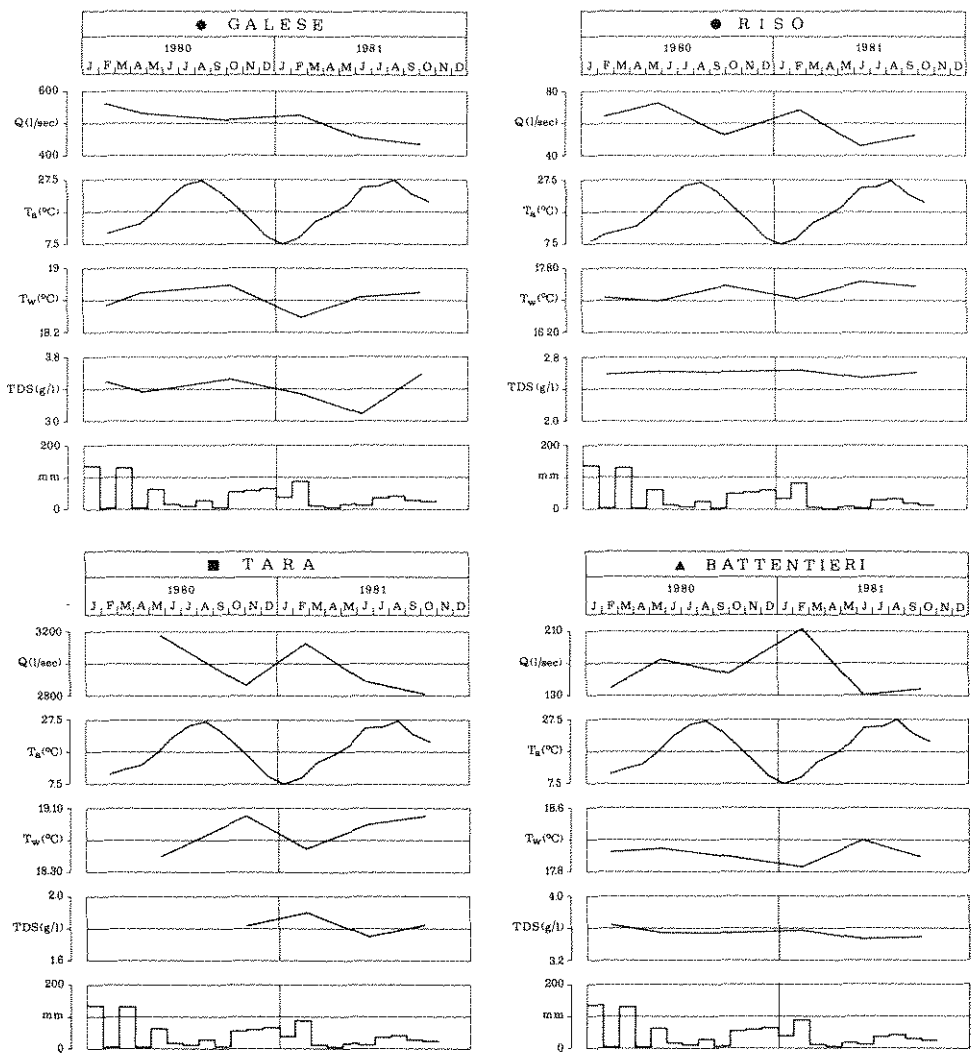

Fig. 4 – Chronological diagrams of discharge (Q), temperature and salinity of waters (Tw and TDS), of air temperature (Ta) and histograms of rainfalls relative to the Ionian versant's springs.

The fact that piezometric heads keep still high along the coastal strip is for the hypotesis of groundwater discharge into the sea through a series of occurrences not yet localized, distributed along the Adriatic coast.

Moreover fresh groundwaters flow on encroaching sea waters, the presence of which was determined by surveys conducted in various drilled wells, some of which penetrating the encroaching sea water; depth of this level is dependend upon piezometric heads in agreement with the known laws governing the equilibrium between the two waters [5, 8, 9].

Groundwater saline content as a rule increases with depth. The lowest values, that is little less than 0.5 g/1, in the top parts of the aquifer, roughly coincide with those peculiar to feeding waters.

Values of about 3 g/1 usually indicate the beginning of transition; generally the ticknesses average from few centimetres to several tens of metres.

3. INVESTIGATIONS AND ANALYSIS OF AQUIRED DATA

Generally springs are located behind the coastal line and made up by a real spring-area, often roughly defined, in which waters of numerous occurrences are gathered; generally sheets of waters' levels are close to the sea level's ones.

A tidal inlet, then, conveys drained waters to the sea. The observations carried out were mostly related to the features of outflow waters as well as the chemical-physical ones.

Furthermore sea-levels and spring water-levels were surveied.

Investigations were carried out on each spring by effecting cycles of daily measurements in fixed stations, by recording some parameters and by measuring periodically some others always during the day.

Fig. 2 shows the daily surveys conducted on the considered springs; particularly this representation refers to the surveys effected on « Vasca di Trani » spring dating 15/10/1980.

From the whole surveys we derive that, in all springs, both saline and water temperature values, during the day, keep almost constant. This is the result of the very modest variations of water levels in the occurrence area beacause of sea level variations due to its periodical oscillations, though limited.

Conversely flow variations found during the daily surveys are completely due to sea level variations brought about by tides affecting the discharge of fresh groundwater into the channels; the variations of daily atmospheric pressure do not affect particularly springs water levels.

Moreover, as for water chemical aspect, pH, dissolved oxygen, CO_2 and HCO^-_3 were taken into account in order to characterize possible variations that waters may undergo in time.

It is known that dissolved oxygen measurements have a precise meaning only if taken near the outlet, and that was not always possible; however, in

those springs that were likely to be observed there was a certain constancy of such a parameter during the day; the variations noted were due to the solar irradiation.

pH, CO_2 and HCO^-_3 show little daily variations probably dependent upon discharge variations and consequently water flow rate.

However if during the day no important variations were observed in hydraulic, chemical and physical parameters, by analizing the data obtained from observations during all period of study, that is starting from January 1980 to the end of 1981, it results that in the long run these parameters show meaningful variations.

Data derived from all observations (Figg. 3 and 4) allow the springs under study to be characterized depending on the coastal versant where they occur.

It was observed that the various springs discharge shows periodical yearly variations related to the groundwater hydrological regimen: in spring of Ionian versant minimum discharge values are found during the first fall months while in those of the Adriatic versant during the same period discharges show the highest values; then one can distinguish a different regimen in the feeding and outflow of the aquifer to the sea.

It is worth to observe that the hydrological regimen in Ionian coastal springs is almost analoguous to the one already observed during the detailed studies carried out on the adjacent Salento's springs: Chidro and Boraco [2, 10].

For such springs too, the flowing regimen proved to be scarcely affected by sea level but linked to the groundwater hydraulic heads along coastal strips.

The relationship between discharge and water saline content (Fig. 5) shows quite evidently the springs groups according to coastal versant, Adriatic or Ionian, on which they occur.

It is noticed that for whole springs of the Adriatic versant the higher discharge values the greater saline contents; while springs of the Ionian versant show a different behaviour, that it is greater discharge values, the lower saline contents.

Only the Riso spring, belonging to the Ionian versant, shows a different behaviour: though having low discharge values shows low saline content values.

Also temperature yearly trend of spring waters further shows the different behaviour of the two groups; for, while Adriatic springs show an increase in temperature with the increase in discharges, for Ionian springs the two parameters are opposite, that is the higher discharge, the lower temperature.

Such a behaviour turns out to be fully evident on the discharge-temperature diagram in Fig. 6; these two parameters have considerable connection.

The Galese spring takes on a particular meaning; it shows an annual characterization of hydrological regimen as result of the connection of the two parameters in study (Fig. 7). Such a connection, however, keeps unchanges the previously conducted observations on general behaviour.

From the observation it results that water temperature comes under a quite limited range of values: for Ionian versant springs, this range averages from 17°C to 19°C, while for Adriatic versant springs from 18°C to 19°.

Conversely the range of thermal variations of each single spring, generally does not exceed 0.5°C.

The saline content of spring-waters, during all investigations time, kept almost constant showing ranges of the order of 0.5 g/1.

These ranges cannot be connected with discharge and temperature values.

Neverthless, it was found that, as for the Ionian group, generally waters saline content trend is contrary to temperature trend.

Finally, the most important fact resulted from observations is that while Ionian versant springs show saline contents within 4 g/l, the Adriatic ones show values even of the order of 15 g/1.

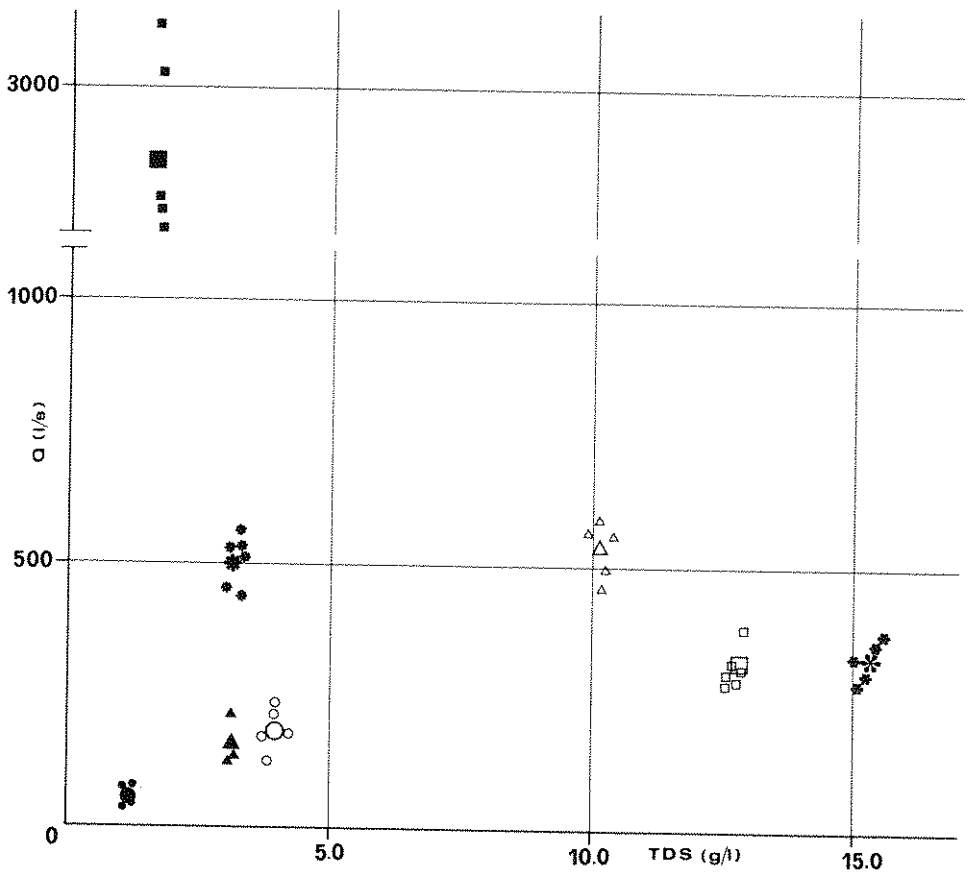

Fig. 5 - Discharge - salt content graph relative to the considered springs. Big symbols are referred to mean values.

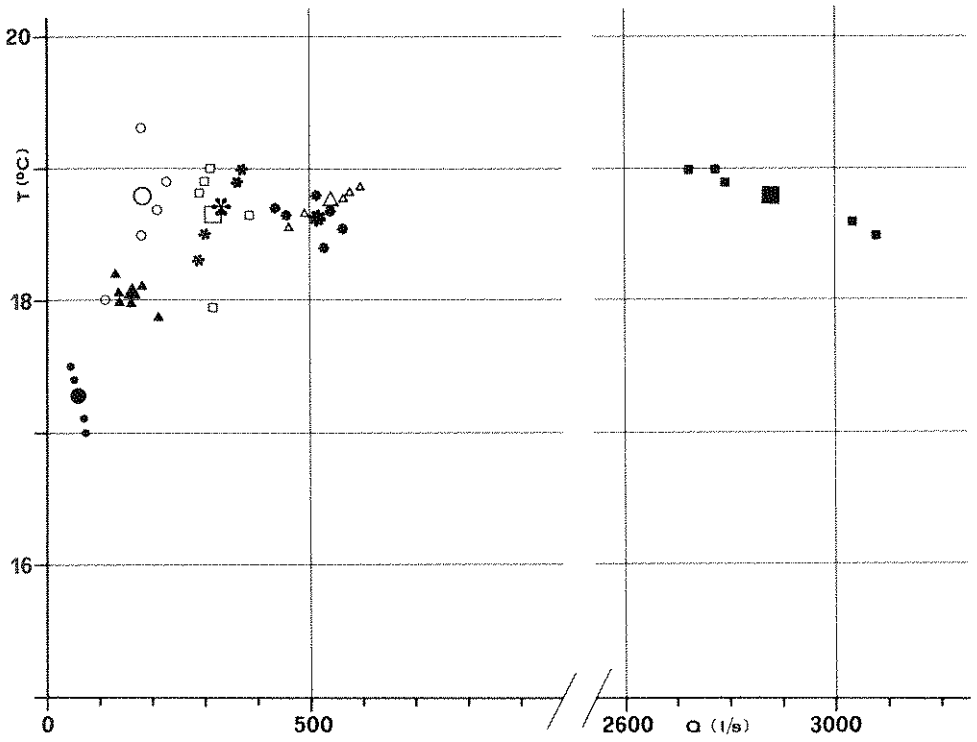

Fig. 6 – Temperature - discharge graph relative to the considered springs. Big symbols are referred to mean values.

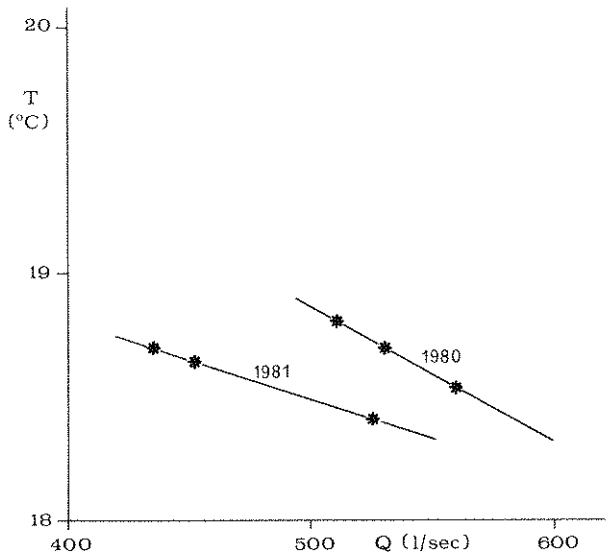

Fig. 7 – Temperature - discharge graph relative to Galese spring.

4. FINAL CONSIDERATIONS

As far, from the exposition we have carried out, one can draw some basic conclusions.

First of all Adriatic springs show similar behaviours, though their saline contents vary in a quite wide range: that must be ralated to the distribution of ground waters saline content in the spring-regions.

In correspondence to Vasca di Trani spring, in Andria's region, some kilometres inland groundwaters, at their upper part, show saline contents not inferior to 3 g/1; conversely in T. Canne's region, where other springs are localized, the isohaline 5 g/1 is present at 8 km inland.

Ionian springs have saline content linked to the ones present in the aquifer at greater depths, while at the upper part saline content values do not exceed 1 g/1 though near the coast.

Water temperature values do point out such a condition. A furthur noteworth factor is that Apulian spring-waters have a maximum of temperatures not exceeding 19°C.

Previous studies on temperature distribution along water columns of Murgian deep wells [4] makes possible recognizing not only where groundwater supply mostly takes place, and by thermal gradients, some main directions of underground discharge up to some hundreds metres depth under sea level, but such studies have indicated the isotherm 18°C as contact line between fresh ground water and encroaching sea water as well.

For, spring waters values are in a good agreement with such assumptions.

Investigations and the consideration of geological situation in the territory under study lead to the assumption, in a completely different way, how present sea waters are involved in the process of underground waters saline contamination.

The Adriatic versant presents a quite active cyclical flow more or less extensive inland; while the Ionian one leds to the assumption of a deep origin of spring-waters involving only underground seawaters which are not recycled through the Ionian coast itself [1].

Further studies have been planned; they will make use of environmental isotopes as well as a series of surveys in drilled wells located upstream of springs, at present being under way.

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