# Operative proposals for resisting the phenomenon of the sea water intrusion along the coast of the eastern Sicily

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**Abstract:** The methods implemented in Sicily to oppose the seawater intrusion along the coastal areas are represented in extremely synthetic way and without structural details.

**Key words:** Vulnerability, Seawater intrusion, Flush boring, Recharge, Submarine springs.

Also along the coast of Sicily the phenomenon of sea water intrusion shows itself. It damages or makes the water resources unusable and this is a serious problem because the water resources are very important for the local populations, economically and socially.
The increase of drinking water request (owing to the town planning expansion along the coastal zones), the extension of the cultivations (especially those in the greenhouses which are very water exacting) and the creation of new industries attached to carriage by sea have produced the fast depletion of the local water supply; the overexploitation of these resources, in the absence or wait of the water supply from other areas, has caused only negative effects, depauperating quantitatively the local water resources and their chemical composition too.
The study of this phenomenon has been begun by lots of Research Institutes through different surveys and controls. Usually the results are modest and restricted to ascertainments of the connection between the irrational overexploitation of the available resources and the progressive seawater intrusion. Only lately an international project promoted by UNESCO-IAEA, Palermo University and G.N.D.C.I. is pointing out the physical-chemical conditions of the above mentioned event occurrence and the possibilities of its constant control, using the natural radioisotopes analyses.
These interventions must be effected in many parts of the world: in fact in the dry seasons only the underground water can be used, while in the rainy seasons there is much water, unused and apparently unusable, which flows into the sea. The more and more exacting use of the underground water has caused the collapse of the groundwater tables, almost everywhere, and consequently a recharge of the same groundwater tables must be assured in order to avoid the total consumption of the resource, the aquifer subsidence, the deterioration of the water chemical and organoleptic composition, owing to the sea water intrusion or the reclimbing of the connate water or the unconfined ground water.
In Sicily, the study and quantitative verification of the phenomenon is advanced in stages: in a first stage, the loss of the coastal ground water flow into the sea has been surveyed by the more recent techniques, such as aerophotogrammetry (thermic infrared) and measures in situ (both into sea and in land). In a second stage, important statistic values, about the above mentioned loss, have been estimated by a very accurate evaluation of the water balance of every hydrogeologic basin, which feeds submarine springs. These chemical-physical analyses of the water extractable by wells, which are situated along the coastal strips, have been effected also in the hinterland, as fast as the limit of the water table reclimbing, i.e. the fresh

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water-salt water interface. These analyses have pointed out the entity of the phenomenon, which has been already denounced by the qualitative depauperation of the water.
In the above mentioned general situation picture also the activity of the O.U. 4.17 of G.N.D.C.I. (C.N.R.) must be considered. His activity has allowed the publication of the "Vulnerability Maps" (1:50.000) of the water tables about some of the principal hydrogeologic units of Sicily: Iblei, Madonie, Sicani and Palermo Mounts; moreover, the same O.U. 4.17 is preparing the publication of the Vulnerability Maps of Trapani Mounts and the Marsala-Mazzara zone. These Maps show the seawater intrusion in the coastal aquifers, pointing out their areal distribution and size.
The interventions have been realized only in that part of the Sicily coast where the overexploitation was appeared more noxious, i.e. in that zone connected to activity of the Augusta-Priolo-Siracusa petrochemical industry. In some points of this zone the presence of the cones of depression with values also greater than –150 meters down the mean sea level has been noticed. The system, which has been realized, is very complex because has been connected with works, which had other aims, i.e. the water supplying of the industrial area and the Augusta town. A government licence allows to divert a discharge of 500 l/s in winter from the Simeto river at the water plug of "Barca di Paternò", which is situated about 60 km to the North of the water exploitation zone. From the clarification-floccualation plant the clear water is subdivided into three parts: a part of it goes to the plant for making the water drinkable, which serves Augusta, an other part goes to the water distribution plant of the Priolo-Augusta industry and a last part goes to the artificial recharge plant of the overexploited water tables of the Priolo-Augusta-Siracuse district. This artificial recharge plant connect the tank where the Simeto water is clarified with a series of injection wells distributed in the district which must be recharged. The water clarification is absolutely necessary in order to avoid the progressive obstruction of the injection wells, which are about 12, have been sunk so that they reach the deeper local aquifer.
It has been demonstrated that it's possible to introduce a costant discharge (near to 50 l/s) in the water table by the injection wells. The absorption of the injected water happens without gushing back phenomena. The effect of the water injected in the water table is controlled by a set of 39 piezometers, which are equipped with fixed equipments. This plant, guarantying a partial decrease of the ground water development in winter and providing directly the industries in this period, allows to reduce the stress sustained by the water tables and consequently resist the seawater intrusion. The positive piezometric variation have been locally high and in particular, in the months following to the winter season, carachterized by injection phenomenon, these positive variations were so high that there was a general elevation of the pizometric levels; in fact they were situated again above the mean sea level and so they could contrast the sea water intrusion along the shoreline (Figure 1).
The carbonate or carbonate-volcanic aquifers of these areas have such intrinsic and extrinsic features that some new interventions can be expected for the first time. In fact the O.U. would want to draw attention to the opportunity to use the flood water of the local streams for the artificial recharge, because the minimum flow water are used for irrigation or industry.
The derivations of all streams and the direct transfers from the stream to the recarghe plant by injection (which have been already realized and whose absorption capacity don't exceed 50 l/s) can't be realized because the drainage basins of the local streams are small and their hydrogeological features are such that the concentration times are very short (at most, some

hours) and the precipitations are frequent, intensive but short. In a first stage, backwater works have been planned. This barrage works are direct (such as dams) and indirect (infiltration cavities).These last kinds of works unites with the existing injection wells and the new reverse drainage recharge plant. The analysis which have been effected shows that the water supply are lower than the request of a new feeding of the water tables. The principal causes of the above mentioned problem are the morphology of some riverbed (in fact it's impossible to realize barrage works, even if leaking), the expensive costs and the negative effect on environmental impact.

On the basis of experiences, which were successful in similar environments, i.e. characterized by carbonate or volcanic aquifers and a Mediterranean or monsoonal precipitations regime (DHOKARICAK, 1991), a direct absorption of floodwater, as much as possible, into the shores could be promoted. In this way the recharge of deeper aquifers would have guaranteed. This kind of intervention is known as "Gravel filled Trench cum borewell with jacket technique". It has been already tested and it has been successful especially in those regions characterized by a seasonal rains regime. The construction methods of these systems are different but all methods look at a better utilization of the torrential water in order to recharge the water tables. In the table 1 the principal features of the nine drainage trenches to realize are listed.

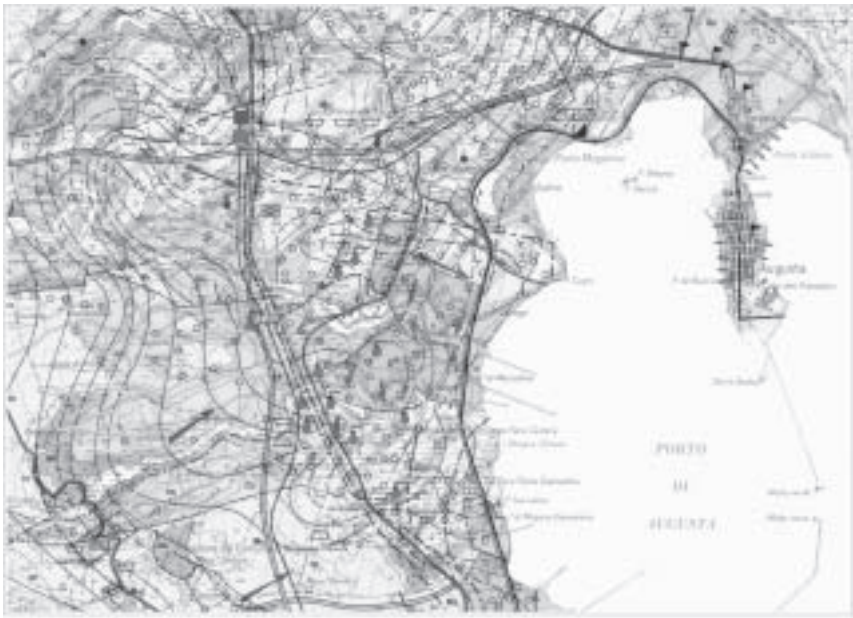


Fig. 1

**Table 1.**

| Name and basin | Surface subtended $km^2$ | Altitude m | Piezometric levels depth | Distance sting max depression km | Time arrival waters recharge -days | Length infiltration ditch m | Number flush boring | Length channel by-pass m | Prev. Length of the drilling m | Prev. Length casing m |
|---|---|---|---|---|---|---|---|---|---|---|
| S. Calogero | 8,25 | 103 | 75 | 2,0 | 77 | 6 | 1 | 160 | 90 | 80 |
| Porcaria | 18,00 | 72 | 60 | 2,5 | 96 | 18 | 2 | 250 | 75 | 55 |
| Mulinello | 8,44 | 35 | 20 | 2,6 | 101 | 13 | 3 | 140 | 40 | 40 |
| Marcellino | 10,40 | 14 | 60 | 2,3 | 0-150 | 27 | 3 | - | 105 | 90 |
| S. Caterina | 3,94 | 50 | 75 | 2,2 | 85 | 15 | 1 | - | 90 | 80 |
| Fontanelle | 4,65 | 26 | 50 | 1,9 | 73 | 22 | 3 | - | 60 | 50 |
| Sorciaro | 13,44 | 51 | 40 | 1,5 | 58 | 18 | 2 | - | 50 | 40 |
| Mostringiano | 8,80 | 61 | 45 | 2,1 | 81 | 24 | 2 | - | 55 | 45 |
| Castellaccio | 6,12 | 52 | 35 | 1,5 | 58 | 22 | 1 | - | 50 | 40 |

The plan to realize is sketched in Figure 2.

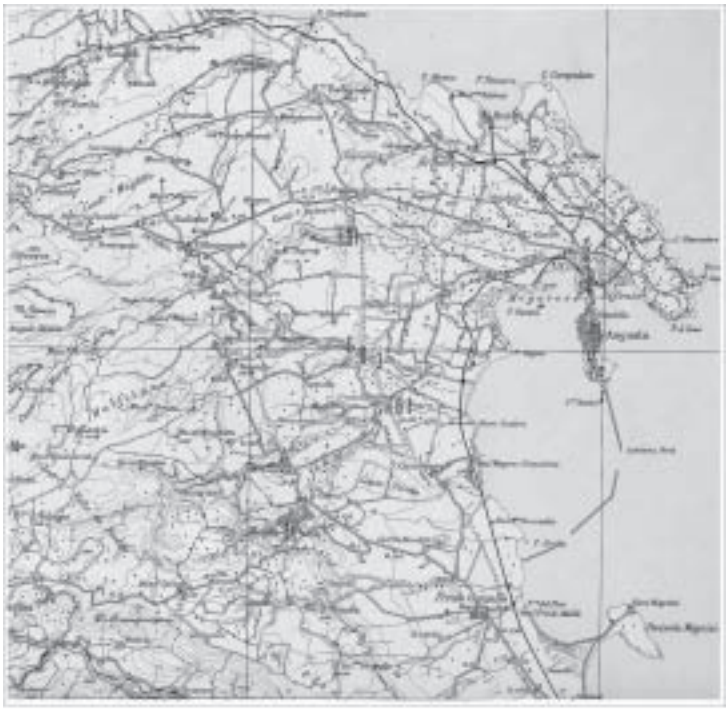

Fig. 2

LEGEND

Infiltration basins

Site

## REFERENCES

DHOKARICAK B. G. (1991): *Grounwater resource development in Basaltic rock terrain of Maharashtra*. Water Industry Publication, PUNE, 51, Maharashtra, India, 281 pp.