# Saltwater intrusion problems in Guzelyurt aquifer

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ABSTRACT

The only source of irrigation and municipal water demand in Guzelyurt area is groundwater. Its coastal aquifer has been pumped at an increasing rate to supply the continuously rising water demand and the equilibrium between saltwater and freshwater bodies has been modified since 1950. About 90 square kilometre irrigated land in Guzelyurt area suffers a very important saltwater intrusion problem due to water pumping over the aquifer capacity. The annual water potential for this area is estimated as 60 MCM while the required amount is above 100 MCM yielding a deficit of 40 MCM. This causes a drawdown of groundwater table and salinization of freshwater sources, as the water analysis of pumping wells indicate.

## INTRODUCTION

Groundwater being protected from contamination and evaporation, usually requires minimum treatment and plays an important role in the water resources potential of the world, especially in arid and semi-arid countries where it is the only source of municipal, agricultural and industrial water supply. But the intensive pumping over the safe yield generally causes groundwater contamination and storage depletion.

The rapid growth of population, extension of the irrigated agriculture and industrial development in Guzelyurt area have been stressing quantity and quality aspects of groundwater resources. The coastal zone of Guzelyurt is the most densely agricultured

area of the country and one of the most important factors limiting agricultural increase of production is the availability of water for irrigation.

The alluvial aquifer beneath Guzelyurt plain is heavily overdeveloped for perennial irrigation of more than 8600 ha orchard crops, and intensive vegetable cultivation. Nearly 3000 wells have been drilled and about 1500 wells are still in operation in the Guzelyurt area. Groundwater withdrawals vary from year to year largely according to the climate and runoff, both of which influence irrigation requirements.

## LOCATION AND CLIMATE

Guzelyurt coastal plain which is slightly sloping towards the sea, has a location on latitude 35 deg 20 min N and longitude 33 deg 15 min E. The gross area is about 21000 ha comprising the lands below 200 m el and has an irrigable lands of 18000 ha belonging to categories I, II, and III.

It is a semi-arid area with a Mediterranean climate of hot, dry summers and cool, wet winters. The temperatures fall below zero in the winter and rise occasionally above 40 deg Celsius in the summer. The rainfall, confined to the months from October to April, average 340 mm in the area. 20 percent of this value is assumed to penetrates the aquifer zone. The area's climate favors irrigated agriculture on a year-round basis. But the main problem is raised by the rapid growth of irrigated areas, where the annual consumption of water has exceeded the safe yield of the aquifer. Thus, in Guzelyurt area irrigable land is more abundant than irrigation water.

## HYDROGEOLOGY

The catchments of the Guzelyurt region are situated largely in alluvial and sedimentary rock terrain. Cnly the mountain uplands are in igneous rock, and there the streams flow on steep gradients through narrow valleys. Within the plain the streams flow in shallow valleys on moderate slopes through the piedmont plain formed largely by cnglomerates. These small streams act as line sources of recharge to Guzelyurt aquifer rather than as surface drainage ways.

The Guzelyurt coastal aquifer rests on an impervious base of gently undulating Pliocene marls 100 to 120 metres below sea level. The aquifer consists of a seaward-dipping sequence of alternately

pervious and impervious strata of gravel, silt and marly clay of pleistocene to Recent age. A continuous layer of marl and clay divides the central portion of the aquifer along the coast into two subaquifers, the lower of which is confined. The subaquifers seen to be naturally connected by the landward wedging out of the clay another two kilometres from the coast, as well as by boreholes (UNDP [3]).

The confined aquifer consists mainly of fine sand, thin sandstone bands and a few gravel horizons each 3 to 6 metres thick. The total thickness of these strata ranges from 60 to 90 metres and the confine layer of clay, marl and sandy marl, varies from 3 to 30 metres. The transmissivity coefficient of the confined aquifer, is between 125 and 475 m**2/day. The highest values were obtained in the southern part of the area. The storativity coefficient computed from measurements of tidal fluctuations, varies from 0.00012 to 0.00051.

The unconfined aquifer consists of sand, gravel and thin lenses of marl and is about 30 metres thick. It is in direct contact with the sea, and further inland it is covered by muddy clay up to 12 metres thick. The transmissivity coefficient obtained by pumping tests in the unconfined aquifer is between 190 and 530 m**2/day corresponding to a hydraulic average conductivity of 8.7 - 20.4 metres/day. However, individual gravel strata may have hydraulic conductivity as high as 30 m/day. The estimated specific yield averages 10 percent but locally may reach 20 percent.

The annual extraction of groundwater has become more than the annual replenishment since 1950. During last forty years, an important amount has been pumped from the storage resulting in a problem of seawater intrusion. The exceptionally high rainfall during wet years caused the water table to rise considerably in the deficit areas. The full effect of that rainfall was not known, but a slight improvement of the water quality was noticed in certain parts of the area (UNDP [3]).

## QUALITY OF GROUNDWATER

Unconsolidated alluvial sediments of quaternary age form the major groundwater reservoirs of the Guzelyurt area. Before 1950's, the quality of the natural groundwater in these alluvial sediments was excellent in terms of its utility for irrigation, domestic or public supply. Total dissolved solids were usually below 500 ppm, and no individual

constituents occurred in excessive concentrations. Only the return flows from irrigation formed the exception in the northern valley.

Figures 1 to 4 show water-table maps corresponding to various years. Figures 5 to 6 indicate the effects of seawater intrusion on the quality of groundwater as of April 1973 and October 1992. Note that any wells operated in Guzelyurt area supplies with chloride contents in excess of 500 ppm is assumed to be contaminated by seawater intrusion.

## WATER BALANCE

Some studies (Ergil [2]) have been undertaken since 1962, and the behaviour of the water table is known due to regular observation by means of very great number of existing wells. But, the water balance is not yet known accurately enough due to the uncontrolled amount of groundwater pumped by well owners. The figure is estimated to be between 26.5 MCM to 86 MCM per year (Electro-Watt [1]).

The average annual replenishment is estimated as 60 MCM/year of which 60 percent is taken directly from rainfall, and about 40 percent from infiltration in stream bed and return flow from irrigation. The water table has declined since 1963 because of increasing extraction exceeded the average annual replenishment. Thus, extraction and return flow have uncertain values. The quantity of groundwater stored in the Guzelyurt aquifer is estimated between 800 and 1300 MCM. However, the useful volume is assumed to be only 130 MCM.

## RECOMMENDATIONS AND CONCLUSIONS

Due to the present demand on the Guzelyurt aquifer its economic utility will be sacrificed in the relatively near future. Therefore, it will be necessary to reduce the draft on groundwater below the safe yield until the aquifer is replenished to a manageable storage condition. This can be accomplished by the combination of reduction in the irrigated area, improving the irrigation supplies to the presently irrigated area, and adopting of modern irrigation methods.

A balanced water budget is needed and must be maintained in order to maximize long-term as well as immediate benefits through correct and adequate management of this coastal aquifer. It is recommended that:

a) More data on the quality of groundwater must be

collected for tracing the natural groundwater flow, for determining the affected area by seawater intrusion and its average speed;
b) The effective porosity of the aquifer has to be determined satisfactorily by means of environmental isotopes studies, since the conventional methods are inadequate because of the existence of semi-confining layers;
c) Semi-annual water-table maps have to be drawn and compared regularly;
d) Improved irrigation techniques must be introduced in order to economize the water presently used;
e) Extraction of water from legal and illegal wells must be controlled and measured. In order to quantify the water extracted from the aquifer law and obligation have to be installed;
f) The intrusion of saltwater cannot be stopped unless the fresh-water table is raised to above sea level along the coast. Artificial recharge must be examined in this area in order to refill the overpumped portions of the aquifer during winter and spring months; and
g) The uncontrolled winter water of the neighboring areas is to be diverted to the Guzelyurt area for replenishment of its aquifer.

REFERENCES

1. Electro-Watt. Feasibility studies for irrigation development in Morphou-Tylliria area. Engineering Services LTD. Zurich, 1973.

2. Ergil, M. Water budget of Guzelyurt area. M.Sc. Thesis,Civil Eng. Dept., M.E.T.U., Ankara, 1989.

3. U.N.D.P. Survey of groundwater and mineral resources, Cyprus. U.N., New York, 1970.

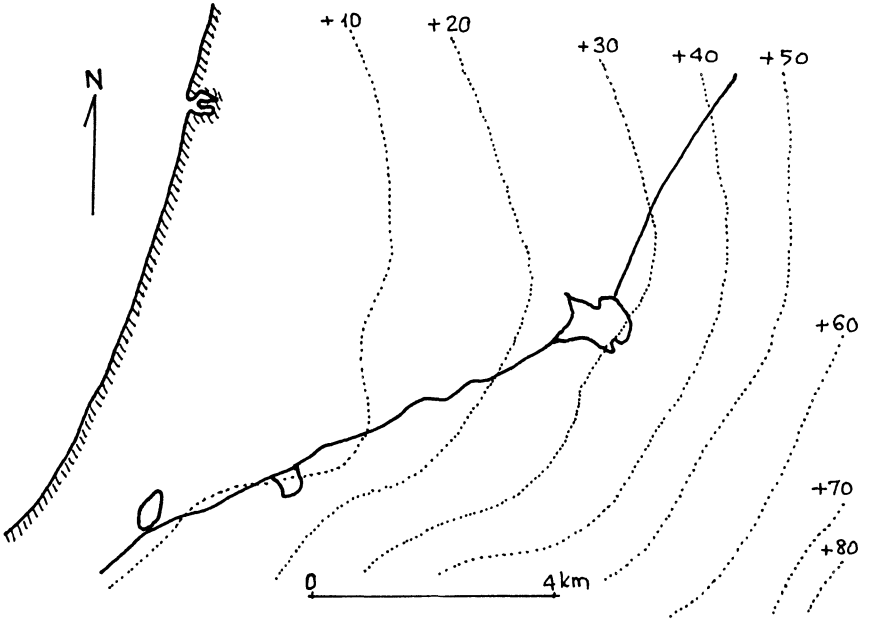


Fig.1 Groundwater level of Guzelyurt aquifer in 1950

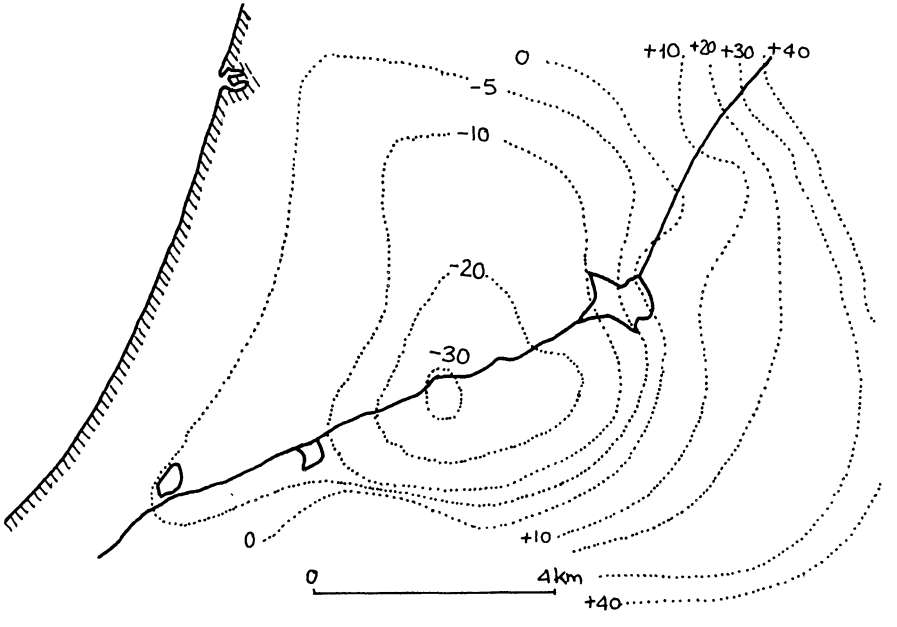


Fig.2 Groundwater level of Guzelyurt aquifer in 1972

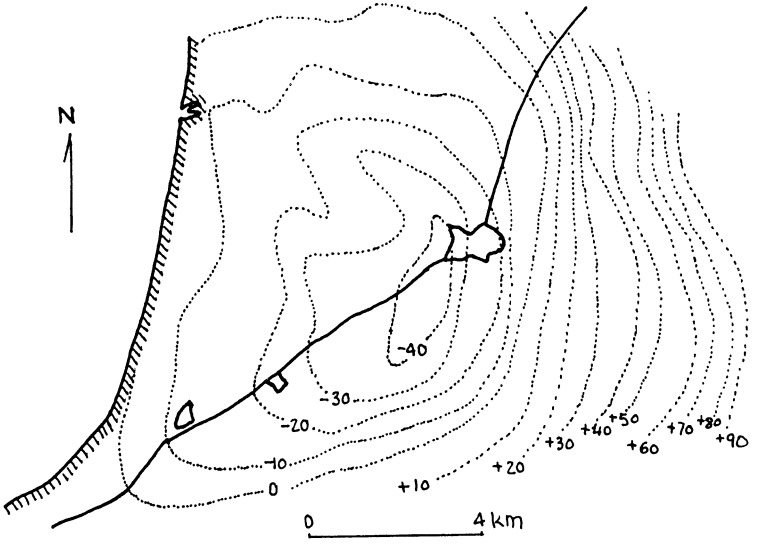


Fig.3 Groundwater level of Guzelyurt aquifer in 1983

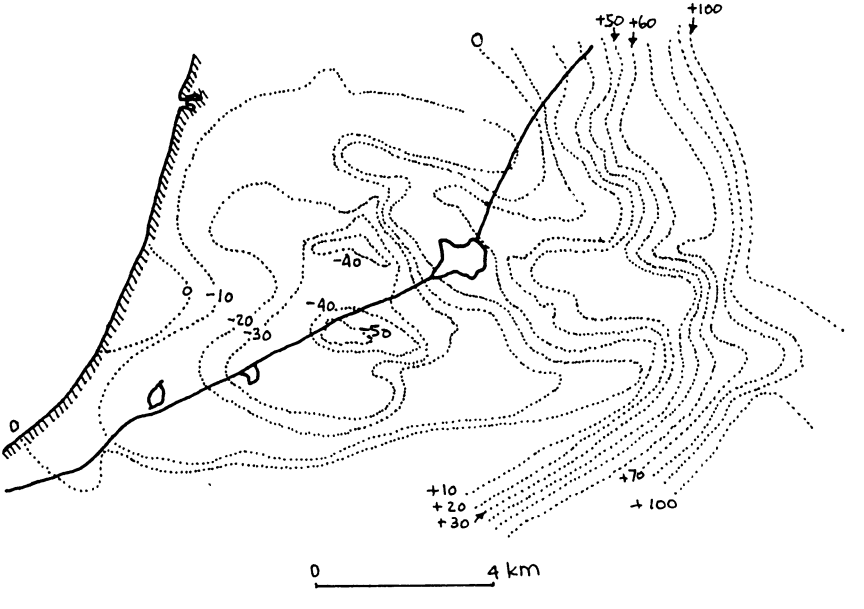


Fig.4 Groundwater level of Guzelyurt aquifer in 1992

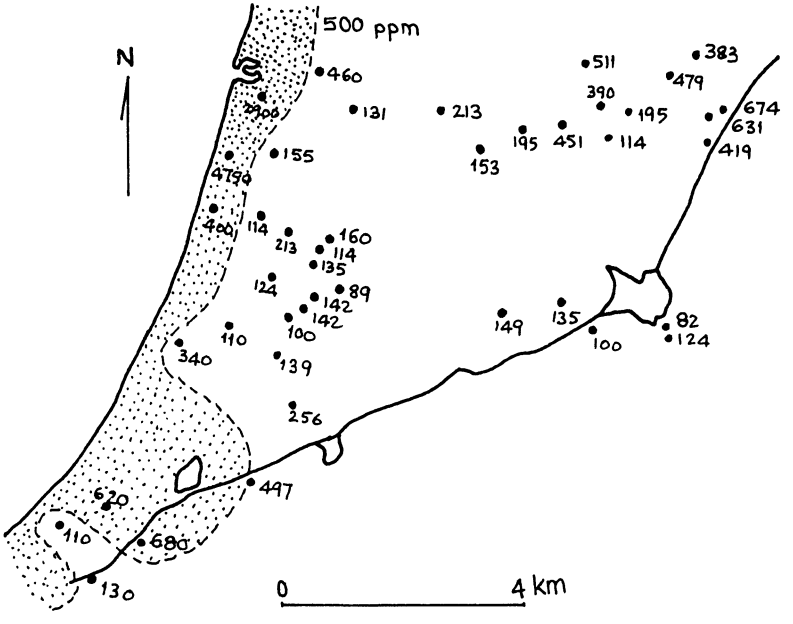


Fig.5 Chloride content of Guzelyurt aquifer in 1973

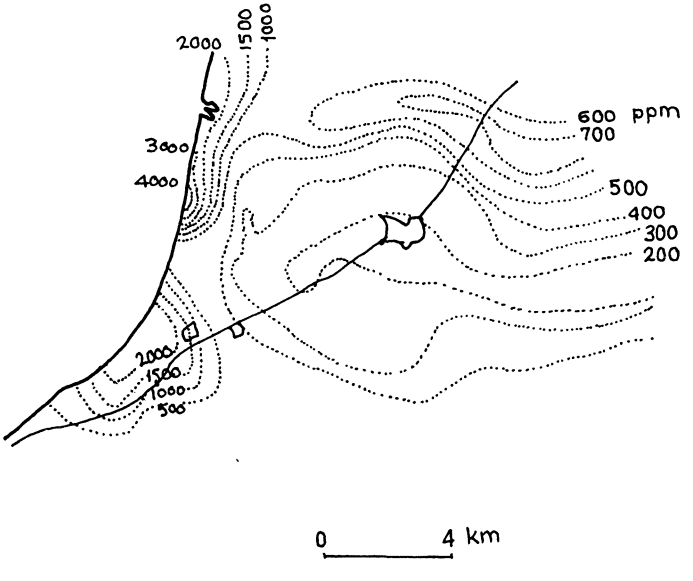


Fig.6 Chloride content of Guzelyurt aquifer in 1977