

# Hydrogeochemical and hydrogeological investigation in the Akrotiri aquifer: identification of multiple salinisation processes and implementation criteria for monitoring networks

E. Milnes, C. Meilhac, D. Yeo, P. Renard, D. Hunkeler, P. Schnegg, F. Bourret

**Abstract**—Identification of the spatial distribution of dominant salinisation processes is crucial for the design of adequate groundwater management schemes, since different salinisation processes require different remedial and conservation measures. Hydrogeochemical fingerprints and hydrogeological criteria were combined in the Akrotiri aquifer to identify the spatial distribution of three main salinisation processes: a) seawater intrusion, b) salinisation related to agricultural activity and irrigation and c) salinisation induced by evapotranspiration and direct evaporation from the shallow water table. Overlaying the spatial distribution of dominant salinisation processes with the existing monitoring network revealed that only seawater intrusion is monitored at present and allowed qualitative evaluation of where the monitoring network should be extended to account for all salinisation processes. Such a monitoring network can eventually provide the necessary data for numerical model calibration which in turn allows simulation of the superimposed effects of multiple salinisation processes and which can be used for the design of adequate groundwater management schemes.

**Index Terms**— Agricultural salinisation, hydrochemical fingerprints, monitoring networks, seawater intrusion

Manuscript received October 11, 2006. (Write the date on which you submitted your paper for review.) The research described in this work was supported by the European Community project SWIMED, contract Nr. ICA4-CT-2002-100004.

F. A. Author is with Centre d'hydrogéologie, Université de Neuchâtel, rue Emile-Argand 11, 2000-Neuchâtel Switzerland (phone: 41-32-7182602; fax: 41-32-7182603; e-mail: ellen.milnes@unine.ch).

Other Authors are with Centre d'hydrogéologie, Université de Neuchâtel, rue Emile-Argand 11, 2000-Neuchâtel Switzerland (e-mail: caroline.meilhac@unine.ch; drissa.yeo@unine.ch, philippe.renard@unine.ch, daniel.hunkeler@unine.ch; pierre.schnegg@unine.ch, francois.bourret@unine.ch).

## I. INTRODUCTION

THE design of adequate groundwater management schemes in salinised coastal areas depends on correct identification and understanding of the different origins of salinity. As examples, Vengosh and Rosenthal [28] and Custodio [5] listed several possible sources, which are not directly related to seawater encroachment but are often found to be superimposed in coastal areas. Such sources can be fossil seawater or ancient saline groundwater [29], sea-spray, dissolution of evaporitic deposits and pollution from anthropogenic activity, such as return flow from irrigation [12], [25]. As an example, Cardona et al. [4] investigated a coastal aquifer in Mexico where they identified three superimposed salinisation mechanisms. They found that dissolution of geogenic salt deposits was the most important factor, followed by solute return flow from irrigation, and then, but only in the vicinity of the coast, by seawater intrusion. They observed that groundwater management had been done in the belief that seawater intrusion was the main cause of groundwater quality degradation, and was based on the successive landward displacement of salt-affected wells. These were rapidly affected by salinisation again, since dissolution of geogenic salt and solute return flow from irrigation, and not seawater intrusion, were the main salinisation mechanisms.

Identification of different salinisation processes is mainly done by means of geochemical investigations, and in recent years considerable work has been carried out using environmental isotopes and tracers to identify different salinity sources (e.g., [8], [15], [16], [29], [30]). To understand the dynamics of different salinisation processes and their implications on the salinity evolution it is crucial not only to identify them in space by means of geochemical investigations but also to monitor them in time.

Usually, in coastal settings, chloride concentrations are measured to monitor the salinity evolution [5]. Although chloride is a conservative tracer, its usefulness is limited if

chloride sources other than the sea are present. If focus is put on the monitoring of seawater intrusion only, the resulting data distribution will have a tendency to be heterogeneously distributed in space, i.e. concentration of monitoring data along the shoreline. In the example of the Akrotiri aquifer, we observed that in areas far from the sea, the salinity increased due to irrigation-induced salinisation within a season, similarly to what Cardona et al. [4] observed in Mexico. Unfortunately, in areas located far from the seashore, the salinity evolution has not been monitored over a long enough period to actually allow evaluation of the dynamics of this process.

Numerical models are often used for management purposes, such as evaluation of future salinity distributions, optimisation of well extraction rates and irrigation schemes or delimitation of capture zones (e.g., [2], [7], [9], [10], [22], [31]). The most important prerequisite for the design of appropriate management schemes by means of numerical models is calibration data from a monitoring network that covers all the involved processes. In many coastal areas, as also in the case of the Akrotiri aquifer, only seawater intrusion has been monitored, although other salinisation processes have evolved in parallel without having been recorded. Depending on the importance of such salinisation processes, the numerical simulation results may lead to wrong conclusions and thus to the design of inappropriate management schemes.

The aim of this work is to elucidate, on the example of the Akrotiri aquifer, how existing monitoring networks can be qualitatively upgraded to allow investigation of different superimposed salinisation processes. Identification of different salinisation processes was done by means hydrochemical fingerprints, reflecting a snap-shot in time [19], combined with hydrogeological criteria. This investigation allowed spatial delimitation of areas where different salinisation processes are dominant. Overlaying the distribution of different salinisation processes with the existing governmental monitoring network revealed areas where monitoring of salinisation processes other than seawater intrusion should be intensified or implemented to yield the necessary hard data set for the elaboration of a numerical flow and transport model, which in turn could be used for the design of adequate management schemes.

## II. GENERAL HYDROGEOLOGICAL CONTEXT OF THE AKROTIRI AQUIFER (SOUTHERN CYPRUS)

The Akrotiri aquifer is located in the southern most part of Cyprus, in the Eastern Mediterranean, forming part of a peninsula (Fig. 1). It is the most important porous aquifer of Southern Cyprus. The southern boundary of the aquifer runs along the edge of a large salt lake. The Akrotiri aquifer has an approximate surface area of 45 km<sup>2</sup> and consists of deltaic sediments, deposited in two big fan deltas, coming from the Goryllis River in the east and the Kouris River in the west. The Kouris River is the largest river in Cyprus and drains a

catchment area of 300 km<sup>2</sup>, extending far up into the Troodos mountains [13].

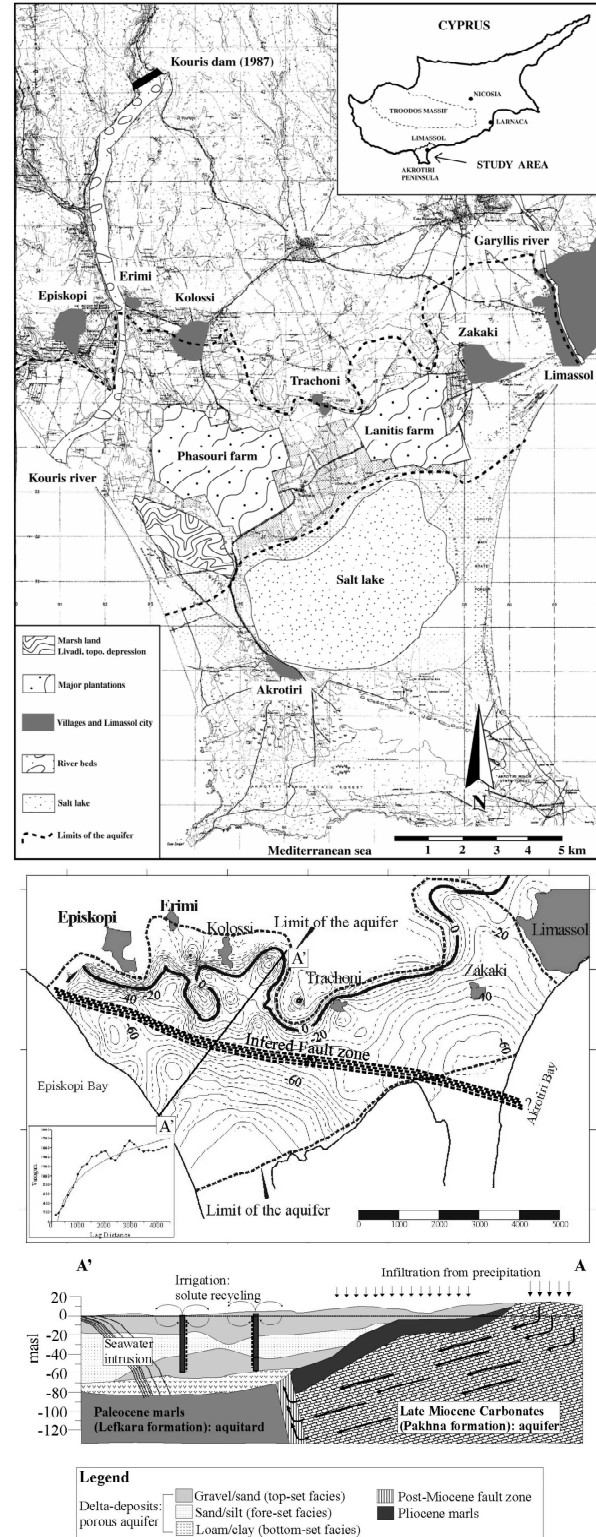


Fig. 1. Top: Main physiographic features of the Akrotiri Peninsula, showing the boundary of the Akrotiri aquifer. Middle: Bedrock topography and Bottom: Conceptual model of the Akrotiri aquifer.

Serious exploitation of the aquifer started with the development of two major fruit plantations, the Phasouri and Lanitis farms, in the late 1930s. The plantations cover an area of approximately 15km<sup>2</sup> in the central part of the aquifer. Since the 1940s, large amounts of water have been extracted for domestic use and, in particular, for irrigation purposes (average 14x10<sup>6</sup> m<sup>3</sup>/year between 1967 and 1977), leading to problems of salinisation since the 1960s.

Growing water demand led to the construction of the Kouris dam in 1987, about 10 km upstream of the Akrotiri aquifer (Fig. 1) which reduced the freshwater recharge. This led to a freshwater deficit and, in consequence, groundwater degradation due to seawater intrusion and agricultural activity became alarming by the end of the 1980's. The authorities declared the aquifer a 'water conservation area' in the early 1990's. This implied an authority-controlled groundwater management scheme to prevent further seawater intrusion (thought to be the only salinisation mechanism), assigning extraction rates to each farmer according to the size of the plots. In this way, the general hydraulic depression in the aquifer, causing the landward directed hydraulic gradients and migration of seawater towards extraction wells should be controlled. Extractions beyond the fixed amount were/are fined and regularly monitored by means of installed water meters.

Fig. 1 shows the main physiographic features of the aquifer as well as the hydrogeological conceptual model which is based on borehole interpretations, geophysical and hydrogeological investigations carried out in 2000 [21].

### III. MONITORING STRATEGY IN THE AKROTIRI AQUIFER

In the Akrotiri aquifer, the monitoring network was extended in the late 1980's to survey the advancing of the seawater intrusion. Most of the effort has gone into monitoring the water table evolution. Water table measurements have been carried out on a monthly basis since 1987 with a good spatial coverage (Fig. 2). Far less effort has gone into monitoring physico-chemical parameters: chloride monitoring was carried out between 1996 and 2000 on a monthly basis on samples taken in the superficial groundwater, mostly located in the vicinity of the sea (Fig. 2). Few governmental sampling campaigns were carried out between 1992 and 1996 for major ion analysis with a far better coverage of the area. However, these campaigns were not systematic and can therefore not be used to evaluate the evolution of the chemical composition with respect to seasonal variations and with respect to different salinisation processes. Since 1998, vertical electrical conductivity logs have been measured in 10 governmental boreholes on a quarter-yearly basis (Fig. 2).

The fairly homogeneous piezometric monitoring network allows reconstruction of the hydrodynamic evolution of the system, providing an adequate data set for a hydraulic calibration of a numerical model. The salinity and chemical data set, however, is scarce and concentrated along the

shoreline. Hardly any data exists of more landward-located salinisation processes. This phenomenon is believed to be wide-spread in coastal areas, where seawater intrusion is often treated with priority, although, in some places, other salinisation processes may be dominant. As an example, several hectares of citrus trees in the central area of the Akrotiri aquifer died within few weeks as a direct consequence of the adopted management scheme. The winter 2003/2004 had been exceptionally wet, causing a significant rise of the groundwater table. For the problem of seawater intrusion this was a lucky situation, leading to a measurable retreat of the seawater front. However, in places, the rising water table led to water-logging and massive salt accumulation in the root zone due to direct evaporation. Although the land owners had correctly identified the problem, they could not increase the extraction rates to lower the water table without being fined by the authorities. Limiting extraction rates is a good approach to prevent or reduce seawater intrusion, whereas, in the described example, increasing the extraction rates to lower the water table would have been the only immediate measure to save the trees from dying. This example illustrates the importance of correct spatial identification of dominant salinisation processes and that one and the same aquifer may require several management schemes.

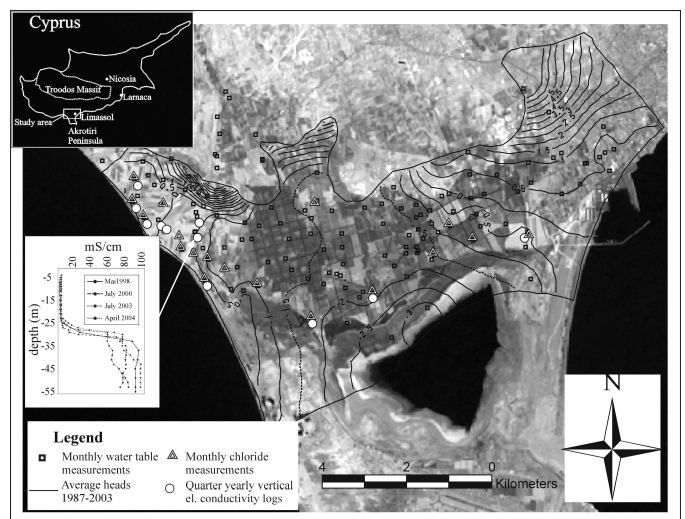


Fig. 2. Existing monitoring network for monthly water table measurements (squares), monthly chloride measurements between 1996-2000 (triangles) and quarter-yearly vertical electrical conductivity logs (circles) shown on an example (graph). The average water table (1987-2003) is shown as black iso-contours.

### IV. IDENTIFICATION OF SALINISATION SOURCES IN THE AKROTIRI AQUIFER

Geochemical methods are a key for the elaboration and cross-validation of conceptual models of salinisation processes, and are thus a prerequisite of efficient water resource management. Groundwater quality degradation is mostly done by both lateral and vertical investigation of the

total dissolved solids (TDS) or electrical conductivity (EC). Fig. 3 shows the distribution of electrical conductivity in the Akrotiri aquifer measured in the superficial groundwater in 2003. The grey area indicates the irrigated surfaces. In the inland areas one can observe intermediate salinities between 1.5 to 5 mS/cm with a wide spread in the salinity iso-contours. In the eastern area, the iso-contours are very close, indicating high concentration gradients which are usually related to the interface between two water bodies with high salinity contrasts (either seawater or lagoon waters). Measurements of the salinity and correlation between this parameter and other fingerprints are the basis to identify different salinity sources.

To understand the dynamics of salinisation in coastal aquifers it is important to combine salinity data with geochemical tools to distinguish the effects of superimposed salinity sources. Then, the geochemical patterns can be interpreted separately in terms of dynamic salinisation processes.

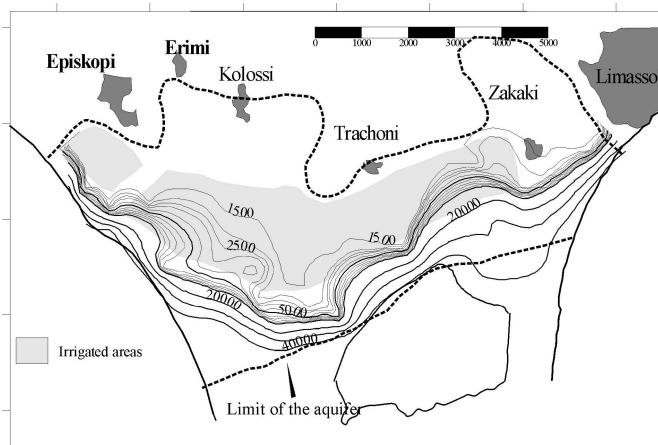


Fig. 3. Distribution of electrical conductivity ( $\mu\text{S}/\text{cm}$ ) in July 2003. Grey area indicates where agricultural activity and irrigation are intensive.

In 2003, a large-scale hydrochemical investigation was carried out in the Akrotiri aquifer to identify the presence and distribution of different superimposed salinisation processes [19]. Three major salinisation processes were identified: a) seawater intrusion, b) irrigation and agriculturally induced salinisation and c) direct evapotranspiration from the water table. Fig. 4 shows the coverage of the sampling locations, revealing the limited access in the area of the western fruit plantation. Major and minor ion analyses as well stable and isotope analysis were carried out on 66 samples.

The procedure that was adopted to interpret the hydrochemical fingerprints was to first identify the samples clearly indicating seawater intrusion. This led to a spatial subdivision into an area dominated by seawater intrusion and an area where other salinisation processes are dominant. Other geochemical markers combined with hydrogeological criteria were then used to interpret the remaining salinisation processes, hence allowing a further subdivision into an irrigation and agriculturally dominated domain and an area

dominated by evaporative processes in the vicinity of the salt lake.

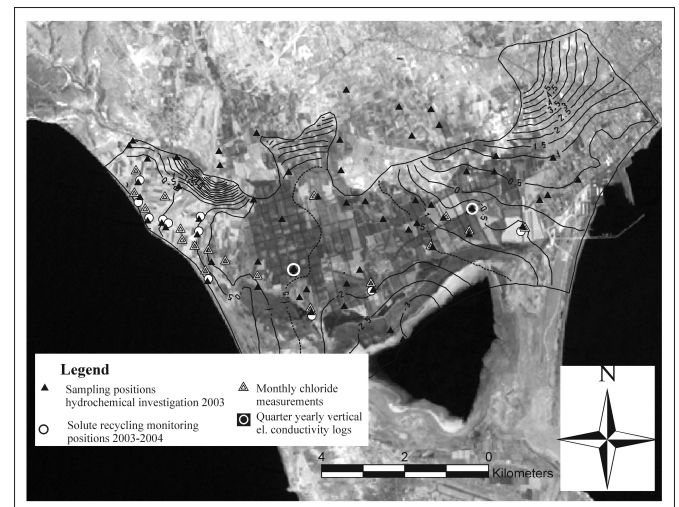


Fig. 4. Map showing sampling locations (triangles) of the hydrochemical campaign carried out in July 2003, as well as the monitoring networks.

#### A. Identification of seawater intrusion dominated domain

The main processes that take place within a pure seawater intrusion context are simple mixing between freshwater and seawater, combined with cation-exchange processes. Due to density differences, seawater encroachment leads to a vertical stratification of salt water below fresh groundwater that can be measured and followed in time in vertical salinity logs (see graph in Fig. 2). Seawater has several typical ionic ratios, in particular Br/Cl with its typical and distinct molar ratio value of 0.0015 for seawater (Jones in Bear et al. 1999) but also Na/Cl and Cl/SO<sub>4</sub> ratios that allow evaluation of the seawater contribution (e.g., [1], [11], [20], [29], [30]). Also, oxygen isotopic signatures combined with chloride concentrations are often used to determine mixing ratios between the freshwater and seawater end-members (e.g., [8], [14], [15], [18], [29]). In the Akrotiri aquifer, the Br/Cl ratio proved to be difficult to interpret, since bromide is a chemical constituent used in the treatment of the plantations.

If simple mixing between seawater and fresh groundwater takes place, there will be a perfectly linear relationship between the salinity or electrical conductivity and the chloride concentration. Fig. 5 shows the relationship between these two parameters in the Akrotiri aquifer and reveals a rather good correlation for most samples. However, one can see that the simple mixing domain is rather wide, since the freshwater end-members that were identified have a large scatter. The samples which are located in the higher part of the simple mixing domain can either result from pure mixing between chloride-enriched freshwater end-member with seawater or from simple mixing between the chloride-depleted end-member, overprinted by an additional chloride source. The samples



located above the simple mixing domain are chloride-enriched, indicating a chloride source other than seawater. Fig. 5 shows, that the combination of the two most frequently used parameters, chloride and salinity, cannot answer the question of different salinisation sources, but does already suggest the presence of several possible salinisation process since the correlation is not perfect.

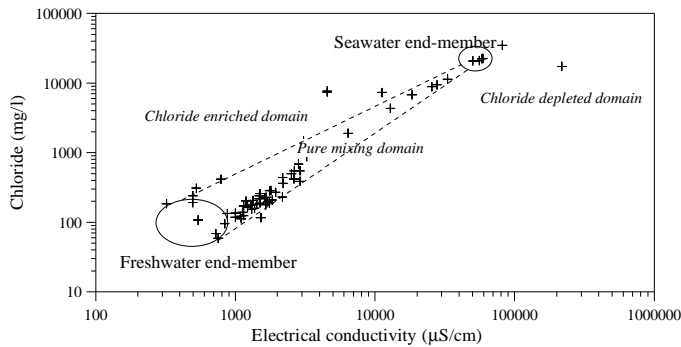


Fig. 5. Relationship between electrical conductivity (mS/cm) and chloride concentrations (mg/l) of the 66 samples with inferred freshwater end-member zone and seawater.

To identify the samples which reflect simple mixing between seawater and freshwater, bivariate diagrams were used and the simple mixing domain was identified between the two main freshwater end-members and seawater. One of the freshwater end-members was sampled in the very western part of the aquifer, while the second one was retrieved in the most upstream part of the central area. Having different geochemical compositions, leads to a scatter in the freshwater end-member pole and thus to relatively wide simple mixing domains.

Fig. 6 shows four bivariate diagrams, correlating the chloride concentrations with the oxygen isotopic signatures, sulphate concentrations, sodium and bromide. The samples located within the simple mixing area for all the shown parameters (black dots on graphs) were identified spatially and interpreted as seawater intrusion dominated samples, shown in Fig. 7. The oxygen isotopic composition was not measured for all samples, and therefore only five samples were identified. The bivariate diagram between chloride and sodium shows a general sodium-depletion for many samples, caused by ion-exchange processes. Ion-exchange can take place in many different contexts, also within a seawater intrusion context. The sulphate-chloride diagram shows the largest scatter. Since the groundwater in the Akrotiri aquifer is mostly rich in oxygen, simple mixing between seawater and freshwater should lead to a linear relationship between the two parameters. This is not the case and suggests the presence of other processes, related to either biological activity or to the dissolution and precipitation of mineral phases (e.g. gypsum).

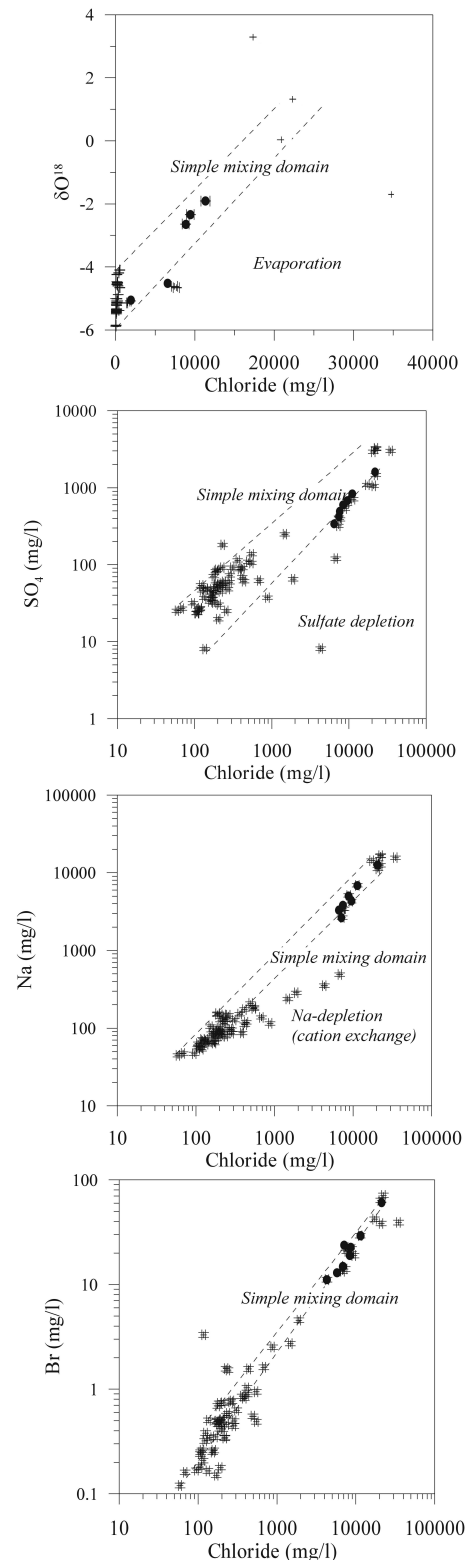


Fig. 6. Bivariate diagrams showing the correlations between chloride concentrations with oxygen isotopic signatures and sulphate, sodium and bromide concentrations.

Fig. 7 shows the spatial distribution of samples that were identified as seawater intrusion dominated, mostly located

along the western shoreline, where the governmental monitoring network shown in Fig. 2 is well implemented. Also, the vertical electrical conductivity logs for these samples reveal sharp interfaces (see example in graph Fig. 2). The samples that lie beyond the mixing domains were interpreted as being dominated or overprinted by other salinisation processes.



Fig. 7. Spatial distribution of sample locations with a dominant hydrochemical seawater intrusion signature.

#### B. Agricultural and irrigation-induced salinisation

Nitrate is the main tracer used to identify agricultural salinisation. In a similar way to chloride, the behaviour of nitrates can be studied with respect to other constituents, such as chloride and oxygen isotopes. Fig. 8 shows the spatial distribution of nitrate concentrations, subdivided into five groups. It can clearly be seen, that the area that was identified as seawater intrusion dominated in Fig. 7 has the lowest nitrate concentrations, whereas the central area, where irrigation and fertilisation takes place reveals nitrate concentrations up to almost 400 mg/l.

Fig. 9 shows two bivariate diagrams of nitrate concentrations versus chloride concentrations and oxygen isotopic composition. The freshwater end-member zone is indicated, showing a large scatter in the oxygen isotopic composition which is believed to be caused by recharge areas at different altitudes. Both representations show a similar, although very vague, general trend. Increasing nitrate concentrations are positively correlated with increasing chloride concentrations and  $\delta^{18}\text{O}$ -enrichment, related to evaporation. The positive correlation between evaporation and increasing nitrate concentrations can be interpreted as an irrigation-induced fingerprint, where the oxygen isotopic composition becomes heavier during evapotranspirations and nitrates concentrate before they are transferred to the groundwater again by irrigation return flow.

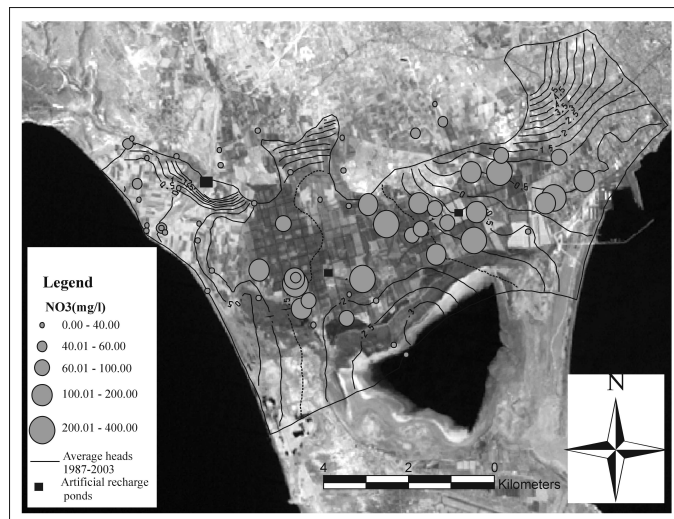


Fig. 8. Distribution of nitrate concentrations (mg/l) in the Akrotiri aquifer in July 2003, subdivided into 5 groups, showing high concentrations in the area where agricultural activity is intensive (chequered area).

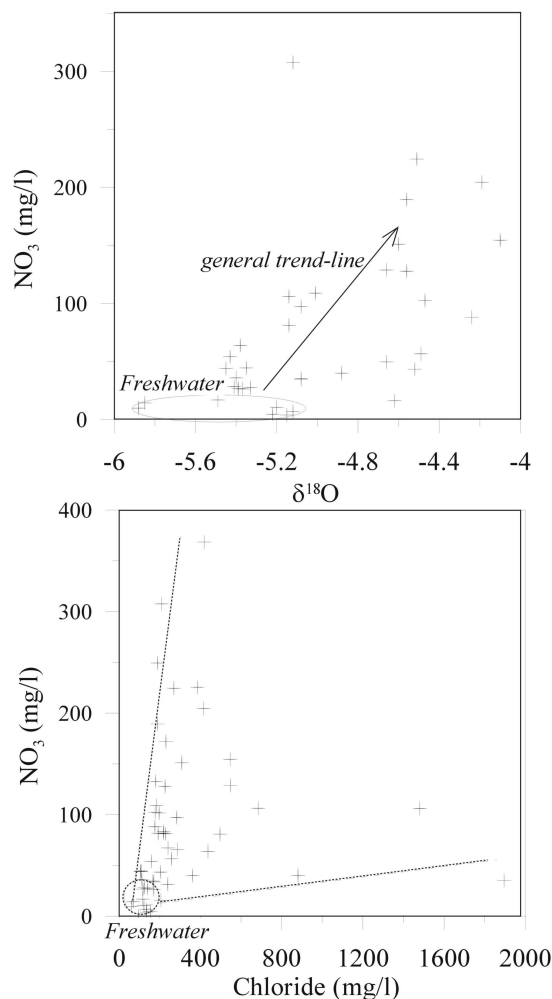


Fig. 9. Nitrate concentrations versus chloride and oxygen isotopic components. Seawater dominated samples have been omitted in this presentation.

The phenomenon of irrigation-induced salinisation was also investigated in two monitoring wells that were implemented within the fruit plantations, the results of one of them is shown in Fig. 3. Since irrigation-induced soil and groundwater salinity had never been mentioned in the area before, soil salinity profiles were made during the irrigation season and at the end of the rainy season. Fig. 10 shows the soil salinity profiles measured on saturated soil paste extraction and the groundwater chemical composition at the monitoring site located in the west (see Fig. 4).

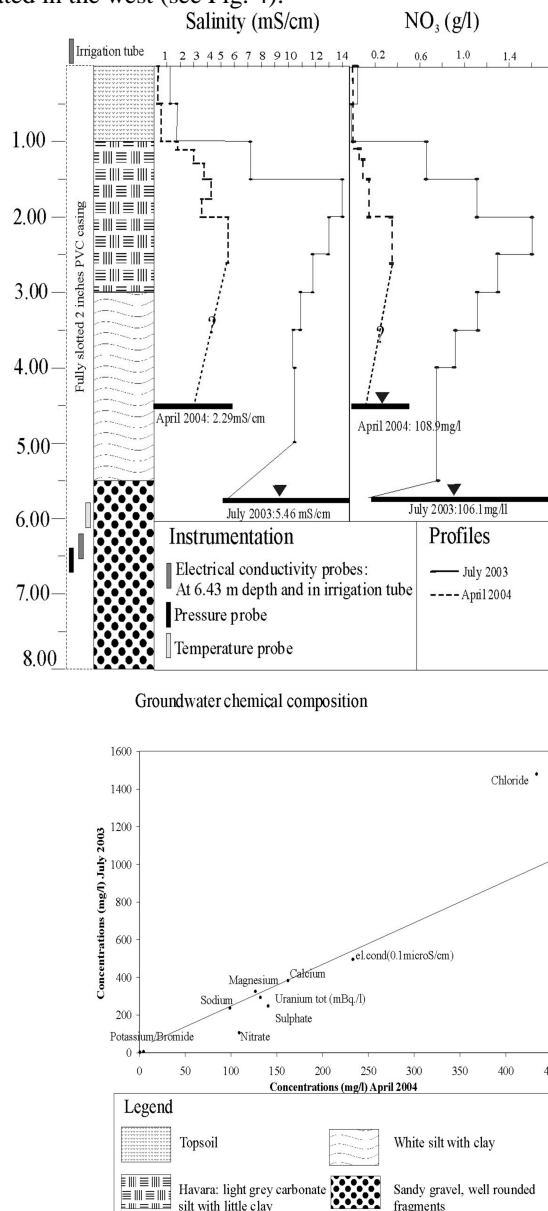


Fig. 10. Selected data from the Phasouri monitoring borehole. Top: Borelog, salinity profiles (mS/cm), and nitrate profiles (g/l) for the extracted saturated soil pastes taken in July 2003 and April 2004. Bottom: Groundwater chemical composition of major ions (mg/l) and uranium (mBq/l) in July 2003 and April 2004.

The soil salinity profile during the irrigation season yielded values of up to 14 mS/cm below the root zone and nitrate concentrations of up to 1.4 g/l, whereas after the rainy season

the maximum salinity dropped to 5mS/cm and to 0.2 g/l of nitrates. This shows that leaching of the unsaturated zone took place during the winter season, transferring solutes to the groundwater, where they contributed to the groundwater salinity and chemical composition. Comparison of the groundwater chemical composition in July 2003 and April 2004 shows a dilution of approximately a factor 2 for most components (Fig. 10). A relative chloride depletion and nitrate enrichment can also be observed. Chloride depletion can be explained by mixing with freshly infiltrated rainwater, poor in chloride, while the nitrate enrichment is believed to be due to leaching of the unsaturated zone and application of fertilizers during the rainy season.

Two perpendicular electrical resistivity tomography (ERT) profiles were measured with a Campus Tiger equipment during the irrigation season and confirmed salt accumulation below the root zone [32]. The electrode spacing was one meter in order to obtain a high resolution of the unsaturated zone and to map out the lateral extent of soil salinisation, since soil resistivity is closely linked to the electrolyte content of the soil matrix. Fig. 11 shows the profiles obtained, expressed in terms of bulk electrical conductivities (inverse of resistivity). It reveals a highly conductive layer (values above 2000  $\mu$ S/cm) at a depth of 1.5 – 3 m. This depth correlates well with the depth where high salinity values were measured in the extraction of the saturated soil paste (Fig. 10).

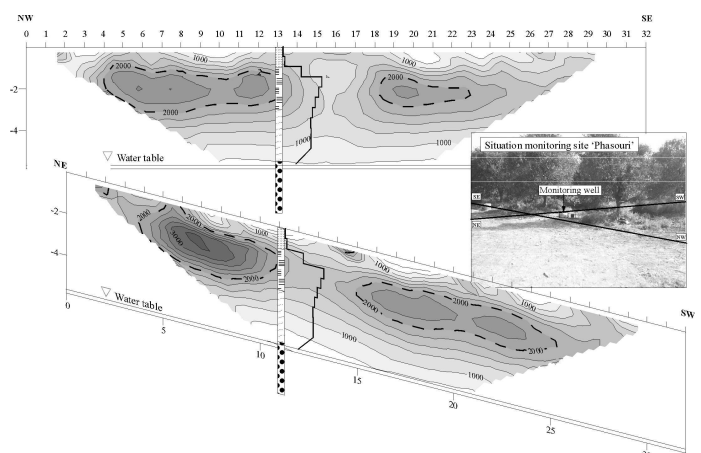


Fig. 11. Two perpendicular electrical resistivity tomography (ERT) profiles intersecting at the monitoring borehole Phasouri (modified after [32]), revealing a highly saline zone below the root zone during the irrigation season. The profiles show the bulk electrical conductivity distribution (in  $\mu$ S/cm and with 250  $\mu$ S/cm iso-contours) within the unsaturated zone. The projected position and lithology of the borehole as well as the soil salinity profile (Fig. 10) are shown schematically along the borehole axis.

### C. Evaporation

Evapotranspiration and evaporation can be of importance in coastal aquifers in areas where the water table is shallow. Tree roots retrieving their water directly from the groundwater or upwards movement of groundwater due to capillary forces can lead to either increased salinity in the groundwater or to

precipitation of salts in the root zone, which can subsequently be flushed down to the groundwater again. Similarly, irrigation enhances evapotranspiration and leads to concentration/precipitation of salts in the vadose zone, which are flushed down to the groundwater during recharge events (e.g., [6], [23], [24]). Evaporation is a process which leads to fractionation of both stable isotopes ( $^{18}\text{O}$ ,  $^2\text{H}$ ,  $^{11}\text{B}$ ) but also to a relative fractionation of major ions (in particular Br and Cl ions), and thus to a change with respect to the typical ratios characterising the seawater composition (e.g., [17], [27]).

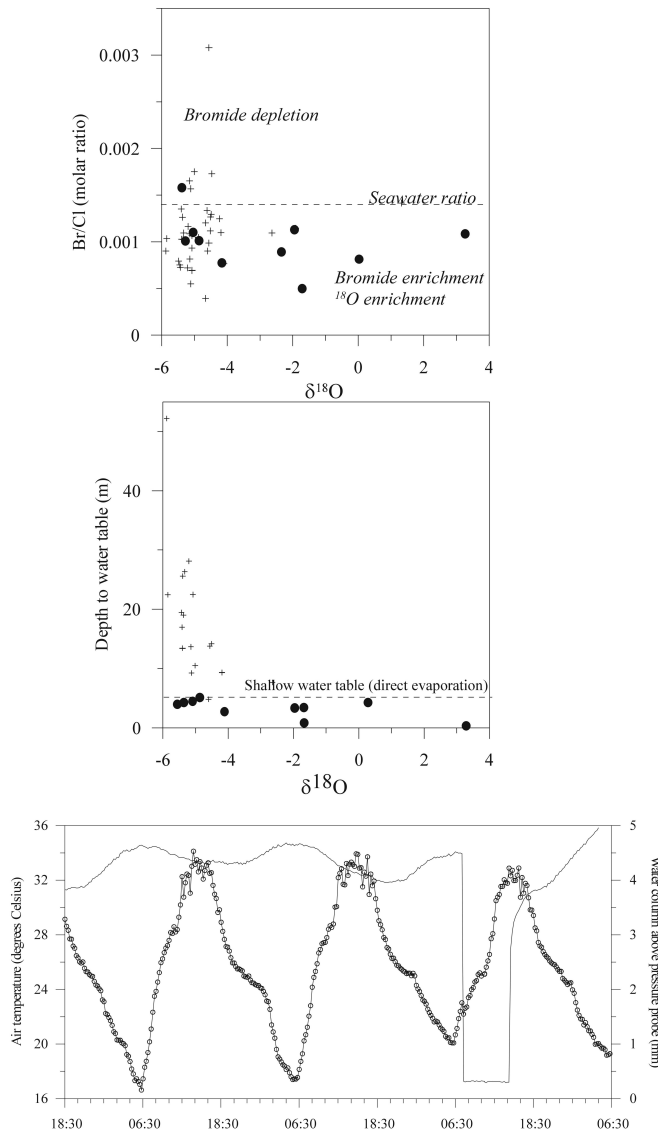


Fig. 12. Top left: Bivariate diagrams showing the relationship between oxygen isotopic values and the Br/Cl ratio. Top right: Graph showing the relationship between the average depth to water table and oxygen isotopic composition. Bottom: Results from continuous relative water table (line) and air temperature (circles) measurements in a borehole located to the north of the salt lake, in a Eucalyptus forest, measured between 11<sup>th</sup> and 14<sup>th</sup> July 2003. At the beginning of the third day, a pumping event can be seen.

As already mentioned earlier the Br/Cl molar ratio, shown in Fig. 12 (top) must not be over-interpreted, since also

agrochemical bromide sources exist. Therefore, the general bromide enrichment that can be seen with respect to the seawater ratio may not be unambiguously related to evaporative processes. Therefore, oxygen isotopic signatures were considered, indicating a general  $^{18}\text{O}$ -enrichment towards the central area, which also correlates with increasing nitrate concentrations (Fig. 9). This can either be explained by direct evaporation from the shallow water table or by solute recycling, i.e. evaporation of irrigation water and subsequent transfer to the groundwater. Fig. 12 (middle) shows  $^{18}\text{O}$ -enrichment in samples taken from areas, where the water table is at a depth of less than five meters. The samples that are marked as black dots are all located in the central area where a large Eucalyptus forest was planted in the 1960's. The same samples (black dots were identified on the Br/Cl diagram, all apart from one sample showing a clear bromide enrichment.

These findings were additionally supported by a further, hydrogeological observation retrieved from a well, located in the Eucalyptus forest to the north of the salt lake. Diurnal air temperature and water table fluctuations were monitored over a period of several days in July 2003 (Fig. 12, bottom). The results suggest that evapotranspiration and direct evaporation takes place from the water table, leading to the observed diurnal water table fluctuations. This is a process which will contribute to groundwater salinisation, since even salt-tolerant plants, such as Eucalyptus trees, will leave most solutes behind.

## V. SPATIAL DISTRIBUTION OF SALINISATION PROCESSES VERSUS EXISTING MONITORING NETWORK

Combining the results from the geochemical investigation with hydrogeological criteria allowed distinction between three main salinisation processes in the Akrotiri aquifer: a) seawater intrusion dominates the western coastline, b) irrigation-induced and agricultural salinisation dominates the central area and c) evaporation related salinisation is found in the vicinity of the salt lake, where it is superimposed on the agricultural salinisation domain (Fig. 13). We believe that other processes, i.e. dissolution of geogenic deposits may be important in places but would require a more detailed investigation.

Fig. 13 shows the spatial distribution of the main areas and the superposition of the three salinisation processes as well as the existing monitoring network for chloride concentration (triangles) and for quarter-yearly vertical conductivity logs (white circles). The existing monitoring network nicely covers the area where seawater intrusion dominates, but the remaining domain, and in particular the area suffering from agricultural and irrigation-induced salinisation remains un-monitored, although salinities in this area may rise up to 7 mS/cm. Potential additional monitoring sites have been indicated as black circles, indicating the areas where the coverage is poor (Fig. 13). Exact implementation design of new monitoring sites should additionally be combined with more detailed and local information and could then be used for regular salinity

control and geochemical analysis, necessary to obtain the required data to understand the dynamics of the different processes.

The hydrochemical investigation, as shown in this work, is only a snap-shot in time and can therefore only be used as an indicator of areas that need to be studied in more detail and to identify the presence of multiple salinisation processes.

Salinity data, which is usually used for calibration purposes of a numerical model, reflects the superposition of all present salinisation processes and can therefore only be useful, when the salinity has been decomposed into the different components in a first step. Such decomposition can for instance be done by means of hydrochemical fingerprints, which can only be obtained with adequate monitoring networks. Otherwise, wrong simulation results may be obtained leading to wrong conclusions. Since groundwater modelling is becoming an ever growing field in applied hydrogeology, it is therefore crucial that the operational hydrogeological approaches adapt to provide the necessary data.

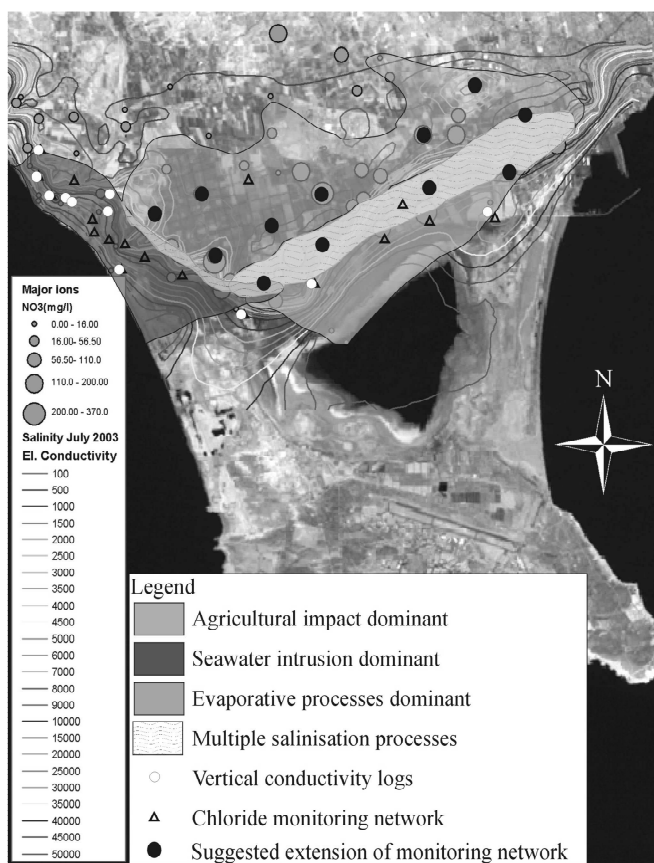


Fig. 13. Spatial distribution of dominant salinisation processes. Existing chloride monitoring network is shown as triangles and quarter-yearly vertical electrical conductivity logs are carried out at locations indicated with white circles. Black circles: suggested extended monitoring locations, particularly covering the central area, where salinisation is related to agricultural activity.

## VI. CONCLUSIONS

The hydrochemical investigation carried out in July 2003 in the Akrotiri aquifer allowed distinction between three main salinisation processes: a) seawater intrusion in the western area, b) irrigation-induced and agricultural salinisation in the central area and c) evaporation related salinisation in the vicinity of the salt lake. The irrigation related salinisation was also observed in a small-scale monitoring well where soil salinity profiles and electrical resistivity tomography revealed soil salinisation during the irrigation season and subsequent flushing during the rainy season: a phenomenon that had so far not been observed in the area. Overlaying the results of the hydrochemical investigation that only reflect a snap-shot in time with the existing monitoring network allowed qualitative identification of the area where the monitoring network should be extended, particularly in the central area where irrigation is intensive and so far no effort has gone into monitoring.

## ACKNOWLEDGMENT

We would also like to thank the Cyprus Water Development Department, in particular Dr. A. Christodoulides for the close collaboration which provided the basis for this work.

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