

Assessment of water saving techniques efficiency using isotopic methods under arid climatic conditions

The Plain of Kairouan – Central Tunisia

Part of the IAEA's Coordinated Research Project (CRP)/ if applicable:

Quantification of Hydrological Fluxes in Irrigated Lands Using Isotopes for Improved Water Use Efficiency



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Introduction:

Agricultural expansions in the Kairouan plain, especially in the Zeroud basin, have caused an over growing need for groundwater. These expansions are largely modified the rate and the quality of groundwater recharge. The optimization of the agriculture water use and the quantification of recharge from the surface require estimates of unsaturated zone water fluxes. Nevertheless, it is difficult to evaluate the vadose zone water flow rates especially with classical methods. Several methods were used to estimate the groundwater recharge (a) lysimeter method, (b) soil water budget models, (c) water table fluctuation method, (d) catchment water balance method, (e) numerical modeling of the unsaturated zone (f) zero flux plane method and (g) Darcy method (h) tritium profiling method and (i) chloride profiling method (Scanlon et al, 2002).

The major aim of this investigation that utilizes a set of hydrochemical and isotopic data is to estimate the evaporation rate of near surface groundwater across the unsaturated zone under an arid condition. Measurements will be carried out for different kinds of soils, with variable groundwater levels beneath the surface. The methodology will be to assess evaporation rates and deep percolation quantities with several tracers such as stable isotopes (^{18}O and ^2H), tritium, trace elements and chloride content of water in the unsaturated zone. This multi-tracer approach will allow identifying the most appropriate indicator to use under arid condition according to culture and soils types. Additionally, the proposed study is to assess the water cycle processes (transpiration, evaporation, deep percolation) in irrigated lands with different irrigation practices and different kind of cultures using classical methods supported by isotope applications. This study will contribute to reach a main result, improving the aquifer balance, by two different ways: a better evaluation of the water input (deep percolation) and by a decrease or either a stabilization of the aquifer exploitation by optimizing the water output for agriculture purposes.

This report provide details about the progress of works done about the measurement of flow and the solutes transport thought the unsaturated zone in relation with agriculture activities.

Site description

The Zeroud basin, which is situated in Central Tunisia (Fig.1) cover an area about 1500 Km². The climate is semi arid with a mean yearly rainfall of 270 mm, potential evapotranspiration of about 1600 mm, and mean annual temperature of 20.4C°. The surface network is mainly represented by the perennial Zeroud Wadi. It collects surface runoff from the bordering highlands (close to the Algerian border) towards the sebkhet Kelbia, that constitutes the discharge area (Bouzaiane and Laforgue, 1986), reflecting regional topographic gradients. In 1982, the Sidi Saad dam was built, with a capacity of 154 millions of cubic meters, on the Zeroud Wadi to protect the town of Kairouan against floods as those of 1969 which caused more than 130 deaths and also to develop irrigation in the downstream area. Before the dam building, runoff represented the major origin of the aquifer recharge. Since 1989, many artificial recharge operations from dam water have been organized in order to ensure the groundwater recharge as major interventions in the massive watershed development program undertaken in the country. These dam releases are carried out during short term recharge programs, according to water resources available in the dam lake.

Since the 1970s, agriculture developed on lands overlying the upper aquifers. In 1985, irrigation system using Zeroud Wadi water which is collected in the Sidi Saad dam was created. During the last decades, nitrate contents in groundwater have largely increased which provide evidence of the significant effect of agricultures activities dominated by over fertilisation (Ben Ammar, 2007). This paper is focused on the irrigated area of Menzel Mhiri. This field is the biggest irrigated area of the plain, with a cultivated area of 200 ha. In this area vulnerability of groundwater resources to pollution would be more significant.

The hydrogeologic system

Hosting formations in the basin of Zeroud are of Miocene to Quaternary period. Schematic geological cross sections established within this study highlighted three dominant facies (Fig.2): Sands and gravels corresponding to the permeable formations lodging aquiferous levels; clayey sands and sandy clays corresponding to semi permeable formations and clays and marls corresponding to impermeable formations.

The alternation of sandy horizons of variable thickness with clayey horizons observed in the basin for a wide saturated zone allows estimating the storage capacity of the reservoir to appreciatively one billion of cubic meters (Heller, 1983).

The first upper sandy level, lodging the shallow aquifer, is roughly limited to 50 meters of depth and groundwater is withdrawn by several pumping wells. Underlying levels, lodging the deep aquifer, are exploited through deeper drilling up to 500 m of depth. Various superposed aquifereous horizons, separated by semi-permeable levels, vary west to east. Under the wadi-bed, the water level is located at more than 60 m of depth upstream and less than 10 m downstream. In the central and western parts of the plain, communication and thus mixture between shallow and deeper groundwater appears to be possible.

The piezometric map of the water table shows that groundwater converge southwest–northeast parallel to the Merguellil and Zeroud Wadi courses (Fig.3). Groundwaters flow from the surrounding relief to the endoreïc depression of Sebkhet El Kalbia, discharge zone of the system. In the west, water levels are located at about 110 m of depth but decrease eastward to 80 m depth near Zaafrana Village. In the Argoub Eremth area, isolines highlight the contribution of Zeroud wadi in the recharge of the aquifer along the wadi and the contribution of irrigation water.



Fig. 1: Location of the irrigated Field "Menzel Mhiri" – The plain of Kairouan – Central Tunisia

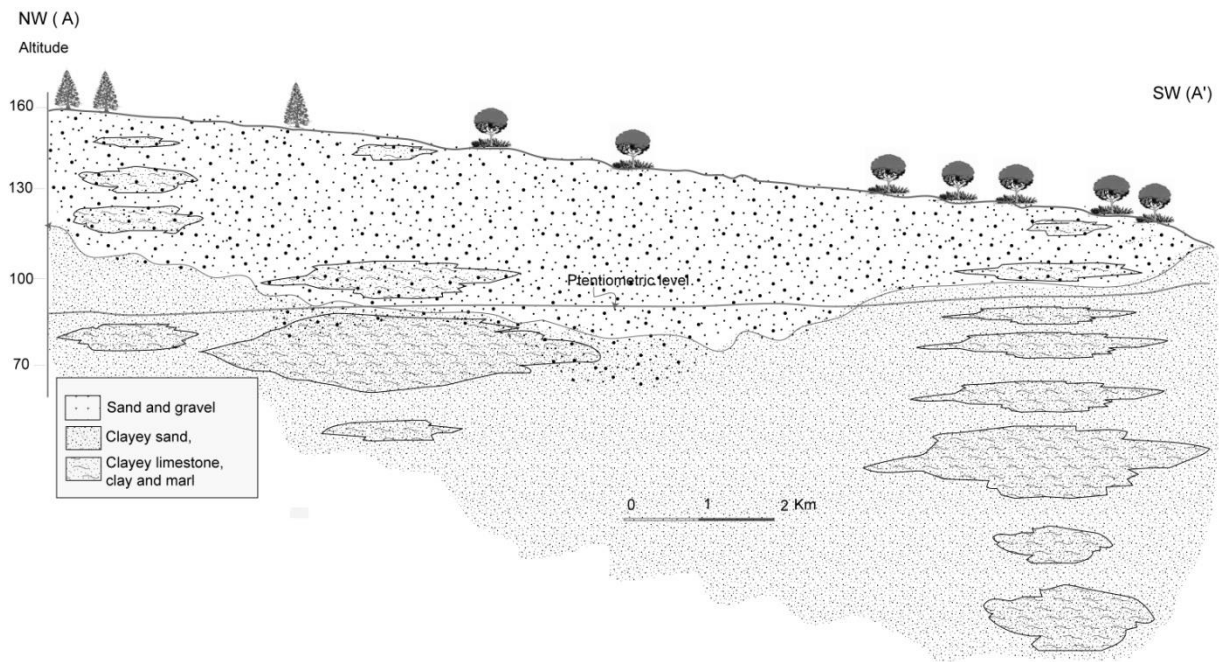


Fig2. Simplified geologic cross section through the Zeroud basin from NE to SW.

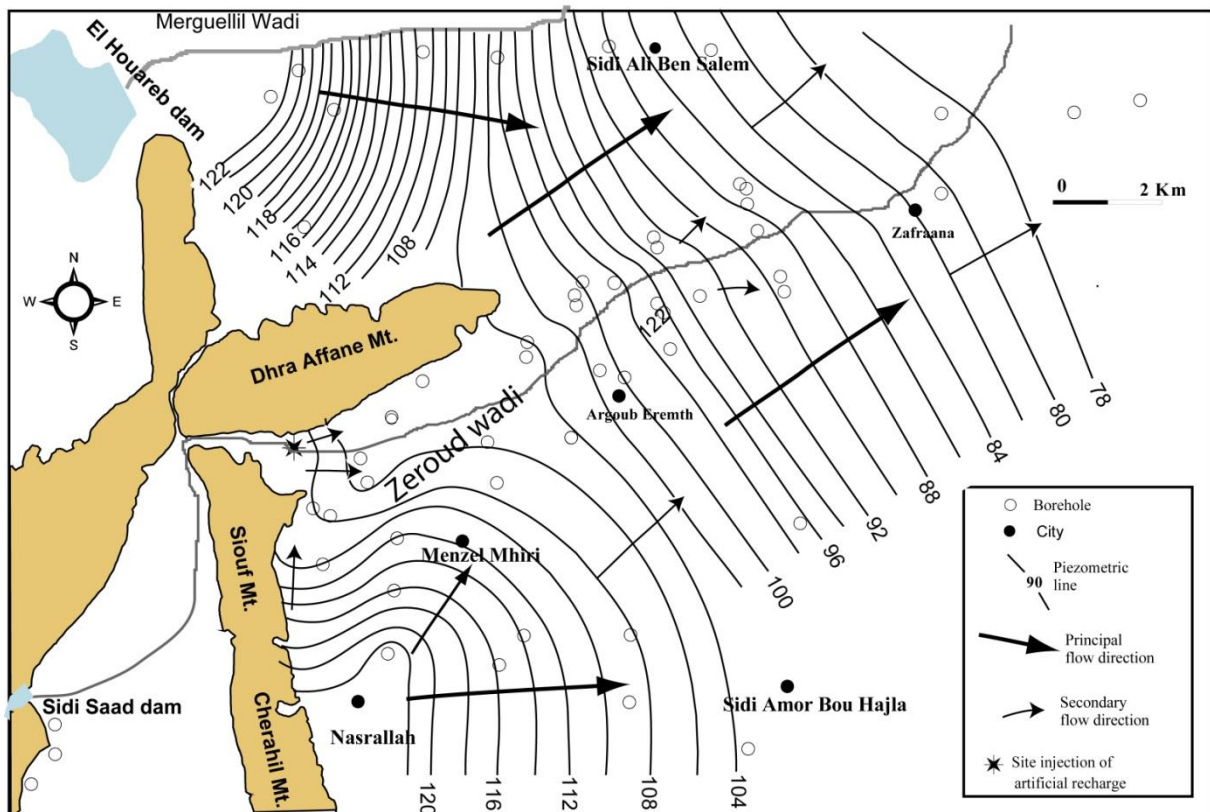


Fig. 3: Piezometric map of Zeroud basin (Mars 2008)

Materials and methods

Three lysimeters have been implemented during January 2009 in the Zeroud basin. The objectives were to improve irrigation application efficiency and its temporal and spatial variability impacting in soil and groundwater. Two lysimeters are under irrigated lands. The first is planted under soil drip irrigation and the second with pivot irrigation. The third is installed under dry soil. From January 2009 to august 2011 8 samples are collected from the three lysimeters. Major elements and stable isotope ratio analyses were performed on these samples.

Soil profiles were sampled to a depth of 1–7 m in cultivated fields, in the Zeroud wadi and in undisturbed natural soils. The samples were collected using a hand-auger each 10 cm interval near the surface and each 20 cm in the lower part of the profiles.

Before the starting of the project (March 2008), four cores have been realized in an irrigated field (p1center, p1border, p2 and p3).

P1: Olive crop, drop-to-drop system

P2: almond crop; drop-to-drop system; close to an irrigation system

P3: almond crop; drop-to-drop system; between rows

During 2009 tow field campaign have been done:

At the first field campaign (March 2009), seven cores have been done in the “Menzel Mhiri” field under different crops and irrigation conditions (A, B ,C, D, E, F, G) . Profiles have been cored by a hand auger and soil has been sampled every 10 cm, the depth of each profile varies from 110 to 500 cm depending on soil conditions. These profiles have been sited according to different crops and irrigation conditions.

At the second field campaign (June 2009), 3 profiles have been also done (A1,B1,C1). The depth of each profile varies from 270 to 740 cm depending on soil conditions. These profiles are carried to study the seasonal variations.

The samples were analyzed for the following: grain size analysis, soil moisture content, EC measurement and chemical analysis. Gravimetric water content was measured in polyethylene bagged samples protected from evaporation in air-tight containers. 50 gram sample was dried in an oven twenty four hours at a temperature of 105°C, the dry soil sample was then weighted and soil moisture content (weight percent) was calculated. Granulometry analysis

was determined on polyethylene bagged samples. Geological formations in cores profiles are mainly sandy with several strata of clays.

The extraction of the interstitial waters from porous media for the chemical analyses is carried out by the elutriation method. In this method, 30 g (MS) of samples of dehydrated sediment are dispersed and elutriated in 100 ml of distilled water (V_{lix}) in a polypropylene beaker for at least two hours, with constant stirring until the stabilization of the conductivity. The lixiviated is then filtered through 0.45 µm filter paper, and then analyzed for different chemical elements. At the end of analysis, a correction is made for the factor of dilution (Gargouri, 1988; Edmunds et al, 1994; Yermani, 2009). Indeed, the concentration of the soil water (C_i in mg.l⁻¹) is related to the concentration of the lixiviated (C_{lix} in mg.l⁻¹) given the relative water content of the soil (W) as in Equation 1:

$$C_i = \frac{V_{lix} \cdot C_{lix}}{W \cdot M_s} \quad (\text{Eqn.1})$$

For the isotopic contents (¹⁸O and deuterium), soil water (100 g) is extracted by distillation under vacuum conditions at 50°C during 8 h, then water is condensed and trapped in tubes under low temperature (-188°C) for isotope analysis (Gouvea Da Silva Rosa, 1980).

Results and discussion

□ Precipitation

In order to better understand the function of groundwater system in the Zeroud basin, it is required to have a perfect knowledge of the input signal. Two (2) stations have been linked to a collecting system where water can be protected from evaporation until sampled. A third station is also sampled directly from the pluviometer collector. 74 events, collected from these three rainfall stations located at different altitude, have been sampled and analyzed for chemical and isotopic composition, since January 2008. Hydrochemical study shows that the chloride content of rainfall decreases with precipitation amounts and site altitude, a mean chloride content of 17.3 mg/l has to be considered for the input signal of rainfall. A local meteoric water line has been calculated from precipitation higher than 5mm by imposing a theoretical slope of 8 reflecting the equilibrium thermodynamic conditions during condensation:

$$\delta^2\text{H} = 8 \cdot \delta^{18}\text{O} + 10.72.$$

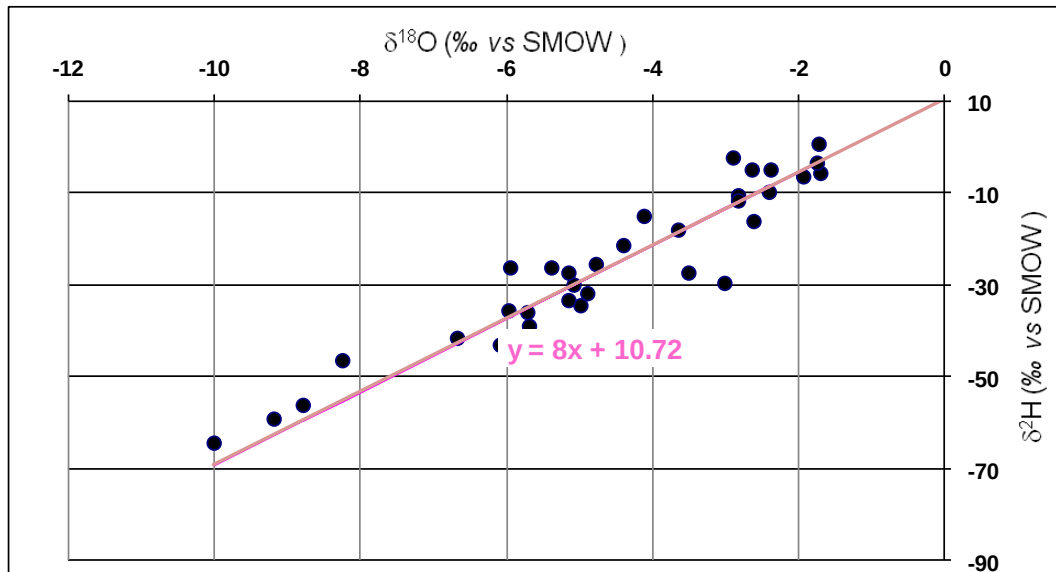


Fig. 4: Stable isotopes diagram for rainfall samples in the Zeroud basin

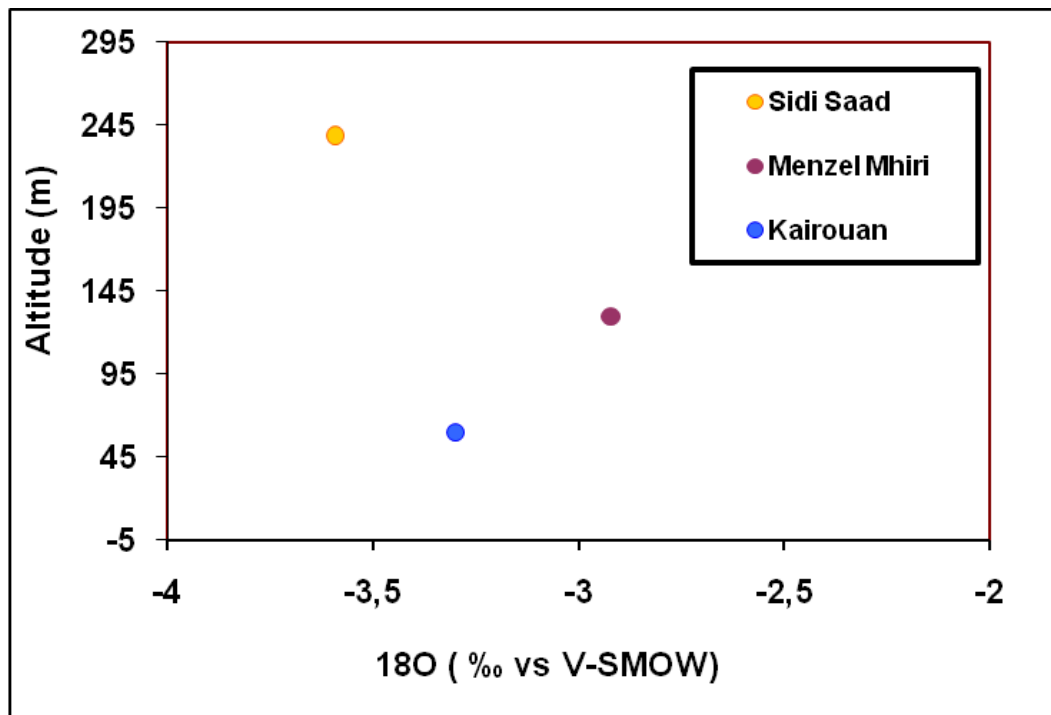


Fig. 5: Isotope variation according to altitude – Precipitations in 3 stations in Kairouan plain

Knowledge of the altitude gradient in a given area makes it possible to determine the recharge altitude of water according to its $\delta^{18}\text{O}$ content. A study of stable isotopes contents shows that rainfall trend to be depleted according to altitude (Figure 5). An altitude gradient of about 0.4 ‰ has been calculated. This result is well correlated with the previous studies (Jribi, 2004).

□ Groundwater

Groundwater salinity, which is highlighted by the TDS values, varies largely from 1 to 4.2 g/l. The TDS increase in the same directions of groundwater flow suggesting that the mineralization is significantly influenced by the groundwater residence time. On the other hand, wells located in the vicinity of the Zeroud Wadi are characterized by low TDS values providing insight into the important contribution of the linear recharge. In the Menzel Mhiri area, southern part of the basin, the high groundwater salinity is indicative of land use agricultural practices in the aquifer on the regional scale.

Nitrate concentrations in the study area vary largely from 0 to 150 mg/l. The great majority of samples collected from wells located on map Menzel Mhiri agricultural region, shows nitrate content exceeding the maximum allowable concentration for human consumption (50 mg/l).

The spatial variability of NO_3 contents suggests that high nitrate concentrations can be attributed to the intensive agricultural activities (Fig.6b). Indeed, the use of fertilizers, largely applied in the Menzel Mhiri agricultural district, has resulted in groundwater contamination through soil nitrate leaching by irrigation water.

Partial pressure of carbon dioxide ($\log(\text{pCO}_2)$) has been estimated with PHREEQC program (Appelo and Parkhurst, 1999) using pH measurement and total alkalinity values (TAlk). The spatial distribution of pCO_2 values was visualized in March 2008 with data of 31 wells (Fig.6a). The $\log(\text{pCO}_2)$ values, range between -1.7 and -2.5. These values are lowest in the Menzel Mhiri area and near the Zeroud River, which represent the recharge areas, and increase according to the groundwater flow direction. The lowest values that characterize the Menzel Mhiri region indicate the significant infiltration of irrigation water, which is largely influenced by the CO_2 atmospheric, and/or related to the infiltration of rainfall in foot of Cherahil Mountains.

The highest pCO_2 values, characterizing the downstream part of the basin, provide insight into the important effect of the groundwater residence times, which permit a long water-rock interaction and microbial reactions; and generate a large concentration of CO_2 . This variation conforms partially with the main groundwater flow directions, indicating that the groundwater CO_2 is somehow controlled by the residence time in the aquifer.

The average $\delta^{18}\text{O}$ and $\delta^2\text{H}$ compositions of the Zeroud aquifer is about -5.6‰ and -34.6‰ respectively. In the $\delta^{18}\text{O}/\delta^2\text{H}$ conventional diagram (Fig.7), groundwater samples were plotted together with the Global Meteoric Water Line (GMWL: $\delta^2\text{H} = 8\delta^{18}\text{O} + 10$) and the Regional Meteoric Water Line (RMWL: $\delta^2\text{H} = 8\delta^{18}\text{O} + 10.72$).

Dam water samples show ^2H and ^{18}O enrichment, which characterize water that has been submitted to evaporation. The slope of the trend line is nearly 5 as recognized for evaporation effect.

In this diagram groundwater samples are classified into three groups:

The first group encloses wells influenced by dam water, located near the injection site of artificial recharge (gate which transfers a flow ranging between 1 and 1.5 m³/s from Sidi Saad dam directly to a preferential infiltration zone in the Zeroud riverbed to ensure the groundwater recharge). This indicates the significant role of the artificial recharge locally in the groundwater recharge.

The second group deviates from the meteoric water line including samples reflecting a low enrichment by evaporation. This enrichment is probably the consequence of the infiltration of an evaporated component likely deriving from the return flow of irrigation water. However, this evaporation process is very low compared with the samples of the first group; this is probably related to the source water irrigation (groundwater or dam water). Indeed, the largely applied pivot irrigation which mostly used the groundwater make lower the evaporation process compared to the use of the evaporated dam water. The third group observed in the $\delta^{18}\text{O} / \delta^2\text{H}$ diagram, includes the rest of groundwater samples. These samples cluster, in the majority, between the GMWL and the LMWL, exhibiting depleted oxygen-18 and deuterium contents, which may point to the recharge of the Zeroud aquifer by rain waters deriving from mixing of Atlantic and Mediterranean air masses produced in high altitude.

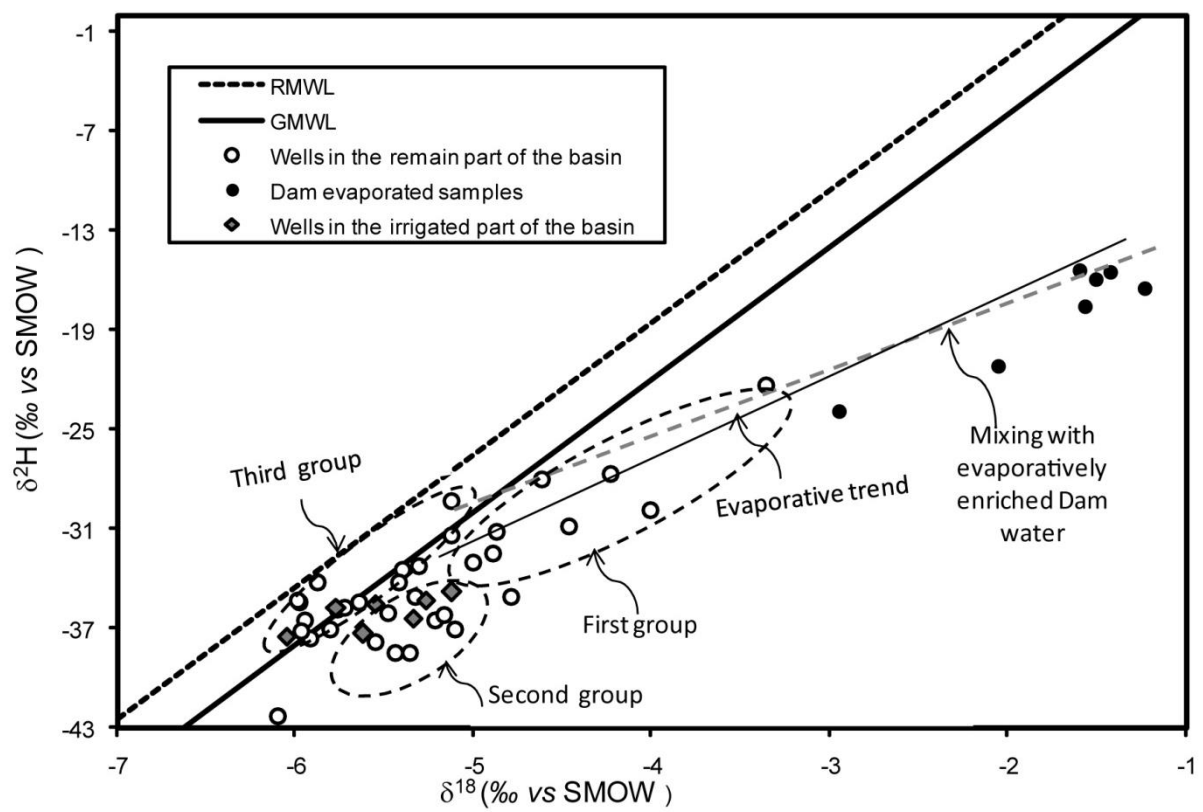


Fig.7: $\delta^{18}\text{O}/\delta^2\text{H}$ diagram

□ Unsaturated zone:

Profiles:

Three types of profiles have been distinguished:

- Typical profile: Higher chloride contents are observed in the upper layer of the soil with an evaporation front located at 10 cm. This type of profile indicates a capillarity process rather than a local recharge.
- Leaching profile: Chloride contents increase with depth indicating a dominant leaching process.
- Composite Profile: chloride content fluctuations related to alternance of recharge and evaporation periods. Chlorides are influenced by a capillarity process and by soil leaching.

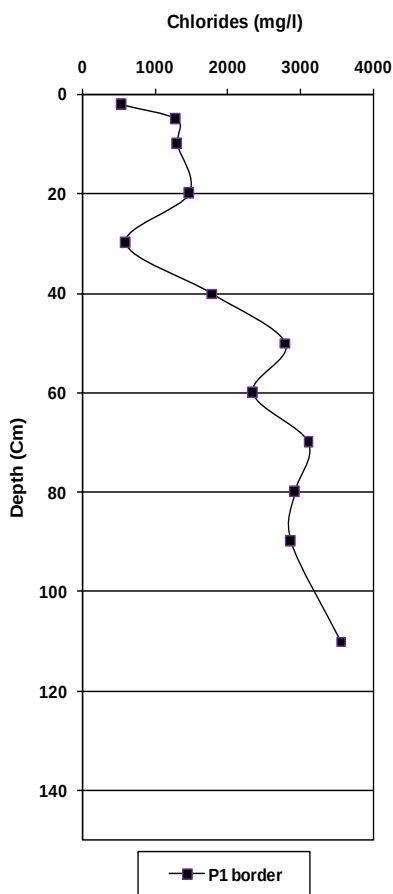


Fig. 8a : Leaching profile

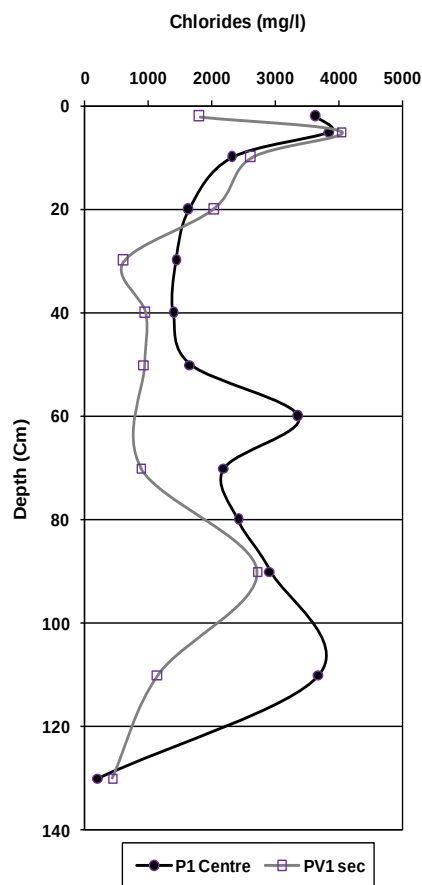


Fig. 8b : Composite profile

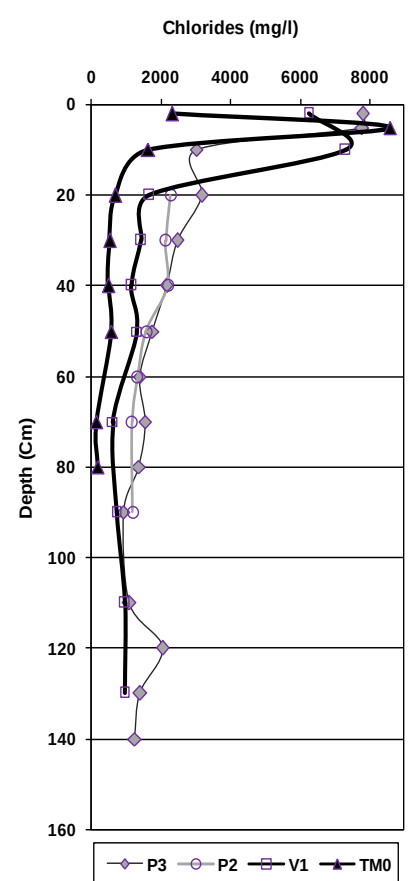


Fig. 8c : Typical profile

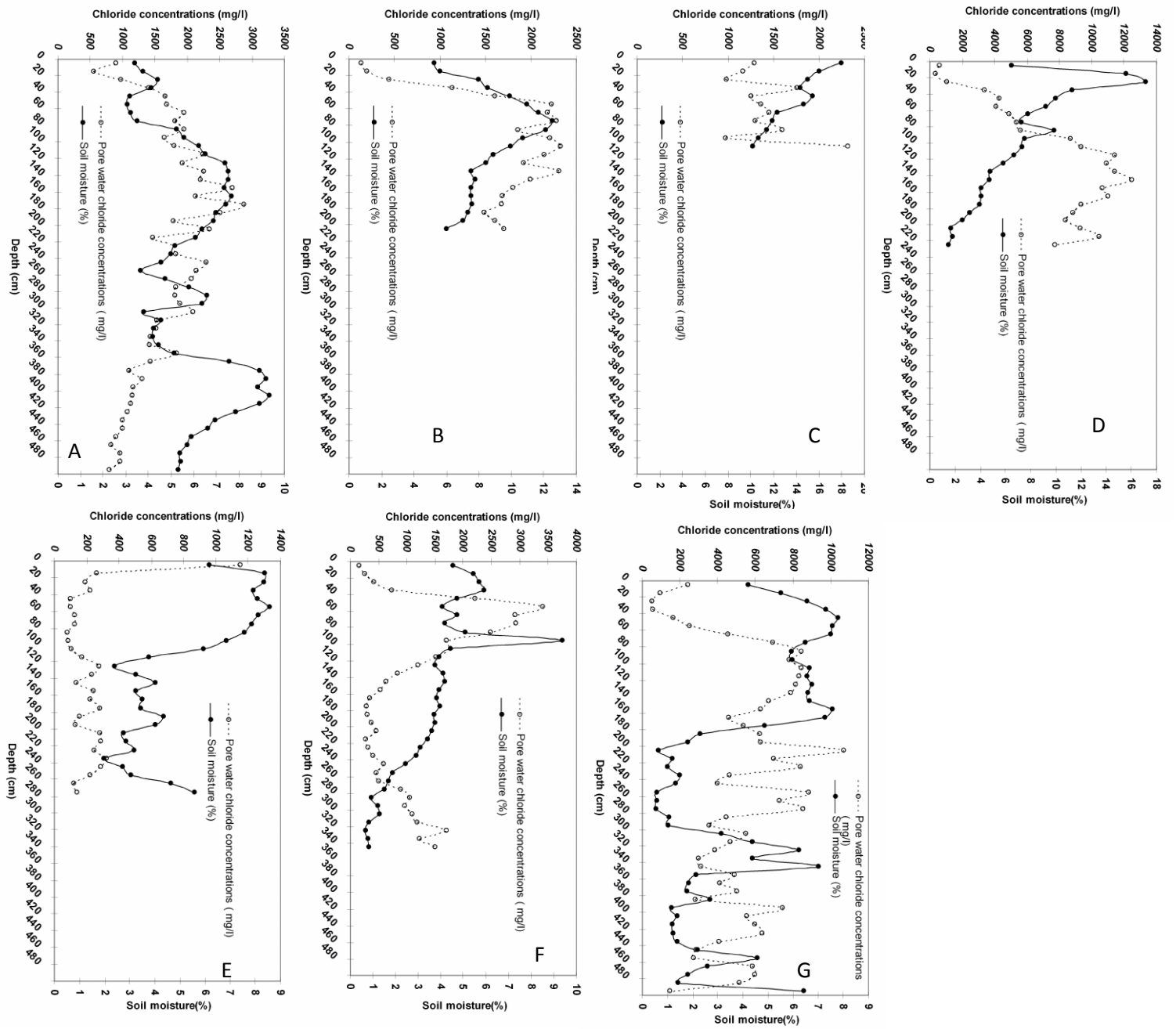


Fig.9: Chloride concentration and volumetric water content of pore-water samples collected at selected boreholes.

Chloride mass balance method (CMB):

Chloride concentrations in elutriate samples from unsaturated zone sites at Manzel Mhiri irrigated field were used to compare possible direct recharge areas with that in the wadis, and to study the evolution of groundwater quality in the shallow water cycle. Chloride concentrations reach constant concentrations within 0.5–2 m. The upper 0.5 meter contains consistently low salinities, indicating that atmospherically-derived solutes are being washed into the profile during rainfall and irrigation events and do not accumulate as salts on the surface.

Recharge was estimated using the unsaturated zone chloride profiling method at all sampling points at each study location. Environmental chloride is deposited on land by atmospheric deposition processes. If the chloride present in the unsaturated zone has atmospheric deposition as its source and there exists no other source in the unsaturated zone for the chloride ions, then under steady state conditions assuming piston flow, it is possible to obtain a chloride mass balance for the chloride flux entering and leaving the root zone as given below.

Thus, assuming an average rainfall chloride concentration of 17.8 mg/l (C_R), an average annual rainfall amount of 270 mm (Q), and average soil water chloride concentrations of 1.61 to 2.05 g/l (C_S) in profiles, recharge rates beneath non-irrigated soils and the Zeroud wadi using the chloride mass balance range from 2.35 to 3.8 mm/year.

Infiltration beneath the irrigated fields is a mixture of 270 mm/year of natural precipitation having an average chloride concentration of 17.8 mg/l with 338 mm/y of applied irrigation water having a mean water chloride concentration of 560 mg/l (The mean chloride content of the irrigation water obtained from the long-term record at Menzel Mhiri area). Thus, assuming an average water input (Q) of 608 mm/y having a weighted chloride concentration of 319 mg/l (C_R) and an average soil zone chloride concentrations ranging between 1395 to 7325 mg/l (C_S) in irrigated profiles, estimated recharge rates beneath irrigated fields range from 26.5 to 139 mm/year (an average of 100 mm/year).

Indeed, groundwater recharge is likely to vary in space even over short distances as variations in soil and vegetation parameters can significantly affect the rates of recharge. Therefore, taking account of spatial variability at locale scale may not critical for water resource assessment but it is important for contaminant transport. The results indicated that the spatial distribution of profiles was influenced by vegetative cover and soil type (differences between profiles could be related to irrigation system (drop-to-drop and aspersion) and to soil lithology).

Stables isotopes in pore-water:

Stable isotope compositions of soil water can be used to reveal information about a number of hydrological processes in soil, including infiltration, evaporation, transpiration and percolation, which is difficult to obtain by other techniques. Because isotopic composition of precipitation may vary seasonally as well as from one event to another, isotopic compositions of precipitation and soil water also provide information about mixing and residence times of water along a soil profile.

The $\delta^{18}\text{O}$ isotopic composition of water extracted from soil samples plotted as a function of depth marked variations between wet and dry period. Stable isotope in these profiles, generally show increasing enrichment towards the surface as a result of evaporation. They showed also that evaporation at the surface of a column soil causes deuterium enrichment near the surface that decreases exponentially with depth. The absence of such an isotopic enrichment for some irrigated soils profiles over the whole profile support the interpretation of flushing after heavy irrigation. It is evident that, in the profiles, the depth distribution of $\delta^{18}\text{O}$ and $\delta^2\text{H}$ clearly separate the upper three meters from the lower section. The oscillations of the isotopic contents have been interpreted in terms of seasonal variations related to periods of wet and dry seasons.

In the natural profile the vertical water percolation appears largely controlled by the «piston model effect" in which the dispersive term is negligible to the convective term. The average displacement of the isotopic composition is obtained by calculating the variation in depth between two points having the same isotopic composition. Indeed for these profiles (profile A) the calculated displacement is about 40 cm per year. However for the others profiles, the dispersive term for the water percolation is dominant which can be related to the dominance of the clay and the silts.

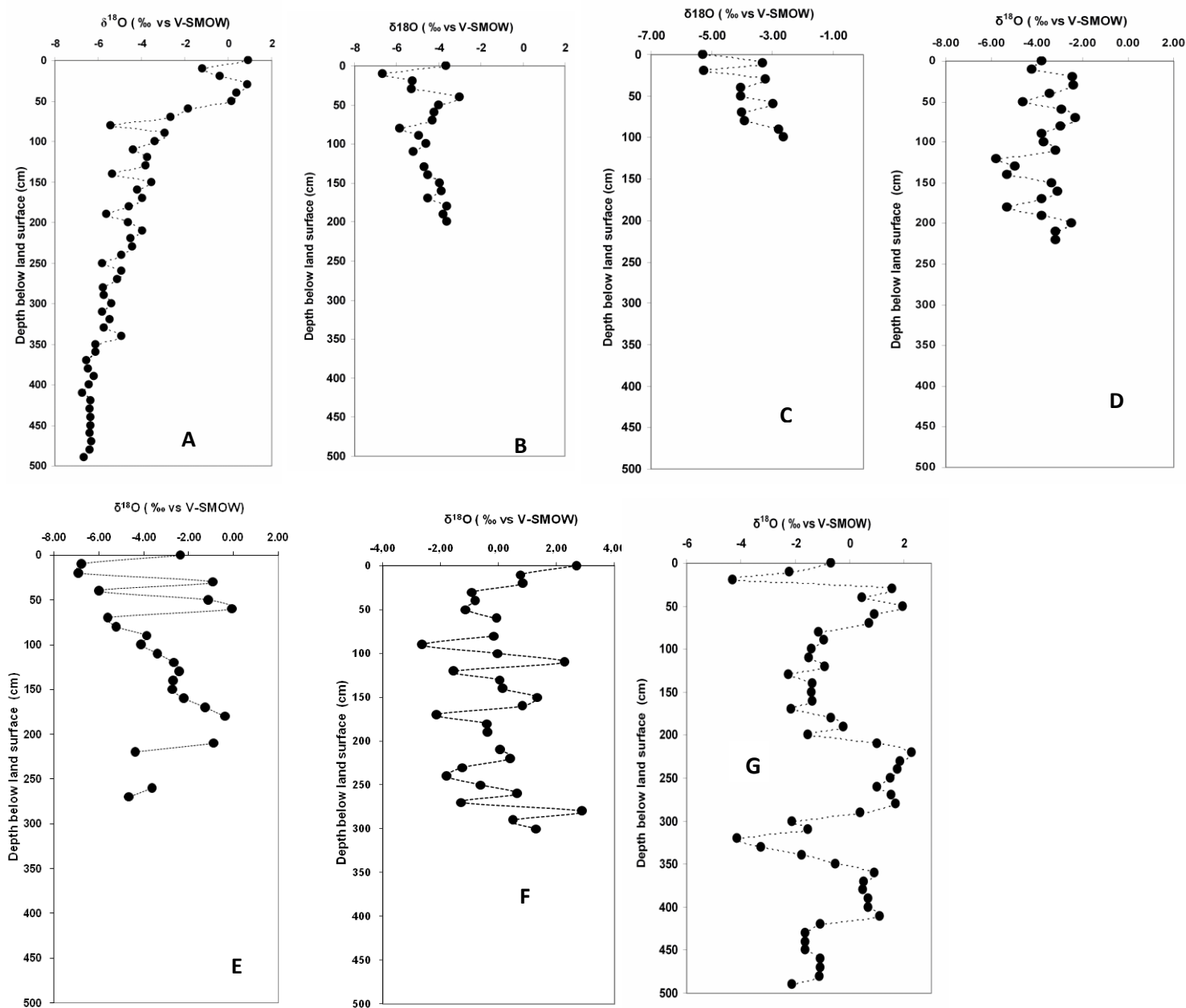


Fig.10: ^{18}O in pore-water

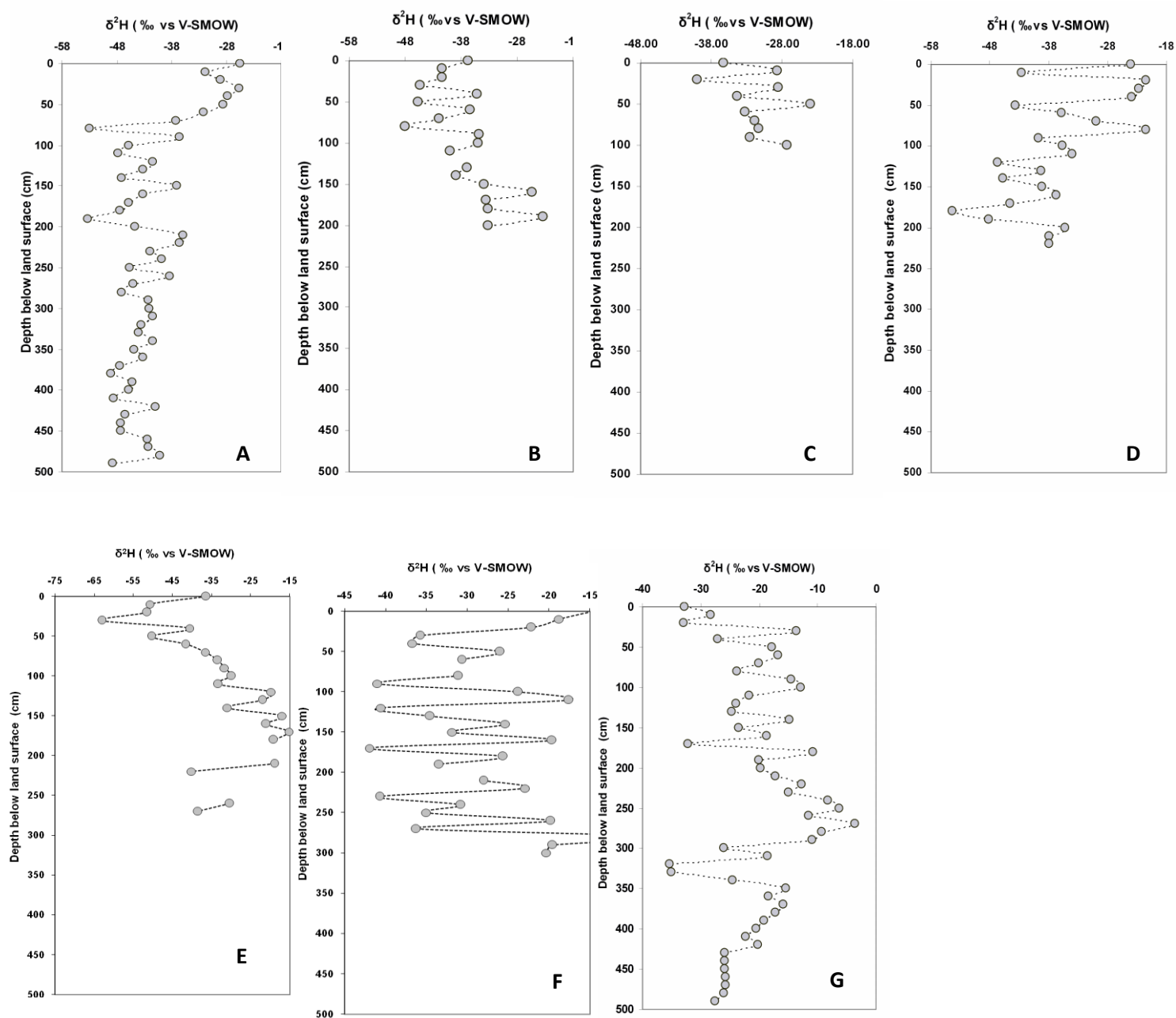


Fig.11: Deuterium in pore-water

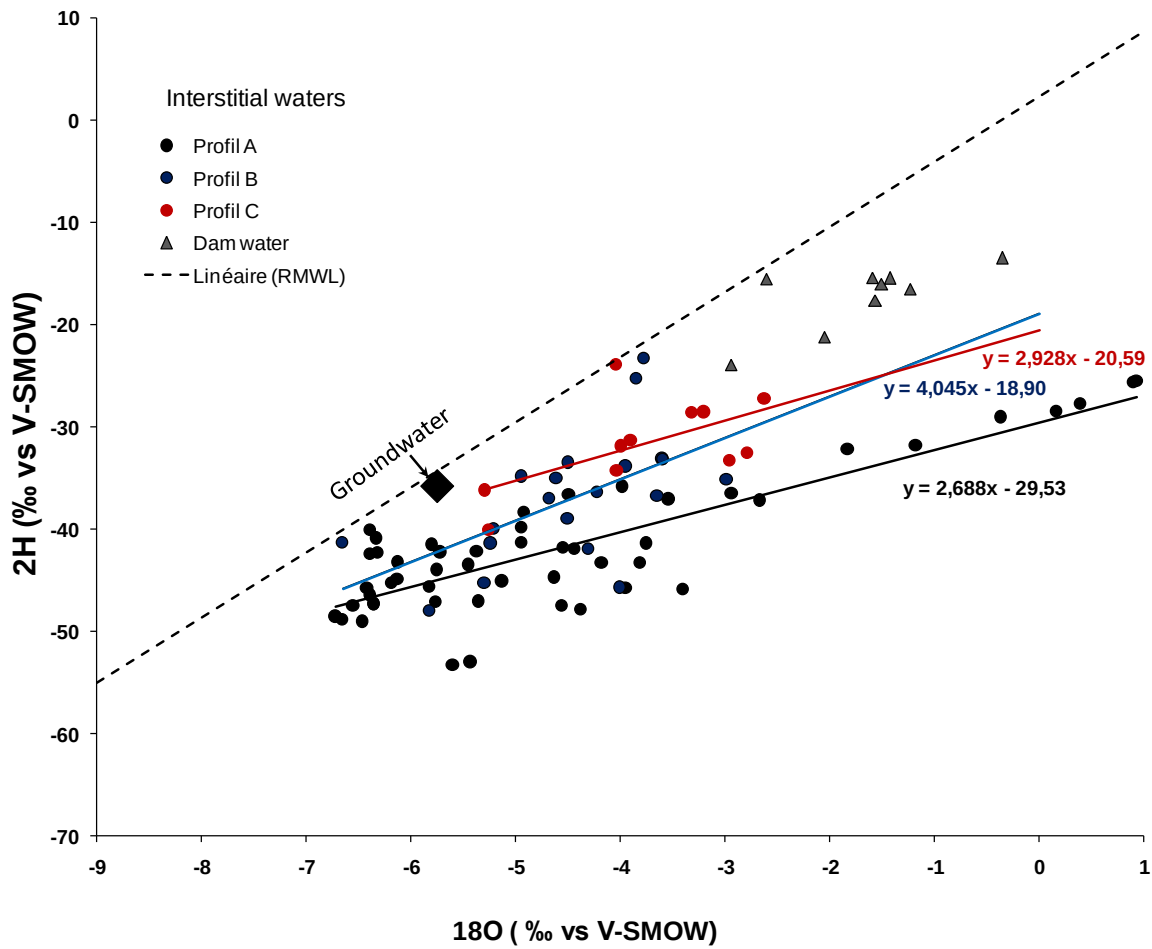


Fig.12: $\delta^{18}\text{O}/\delta^2\text{H}$ diagram for pore-water in A, B and C profiles

Isotopic model

A soil containing a shallow aquifer with an isotopic content (δ_{res}) and a certain ion concentration (C_{res}), when submitted to an atmosphere with a relative humidity (h) and with a water vapor isotopic content (δ_{at}), if not recharge by precipitation, will dry and the mechanism of water transport will set up under its two liquid and solid forms.

After a certain time t , the permanent regime during which the humidity fluxes are invariable will establish. Stable isotopes content (^{18}O and ^2H) profiles will take an exponential sharp from the surface to the aquifer. A characteristic isotopic profile for a soil submitted to an evaporative regime under flow equilibrium (Barnes and Allison 1983) shows two parts:

- A zone where the transfer is in vapor phase and the isotopic gradient is positive. The profile varies from a minimum value at the surface ($\delta_{at} + \varepsilon_{(1-v)}$) to a maximum value (δ_{ef}) located at the evaporation front with a Z_{ef} depth. It is a diffusion zone where both evaporated and atmospheric vapor fluxes are mixed;

-A zone of a composite transfer of liquid and vapor phases where isotopic contents decrease from δ_{ef} to $\delta_{reservoir}$.

The evaporation model of Barnes and Allison 1983 has been applied for the cores A,B and C profiles according to the oxygen 18 content. Profile A takes an exponential sharp from the surface to the ground. The functions reveal a good linearity with R^2 equal to 0.86 and a good agreement is observed between calculated and measured oxygen 18 content. The mean evaporation rates calculated according to this model is about 20 mm/year.

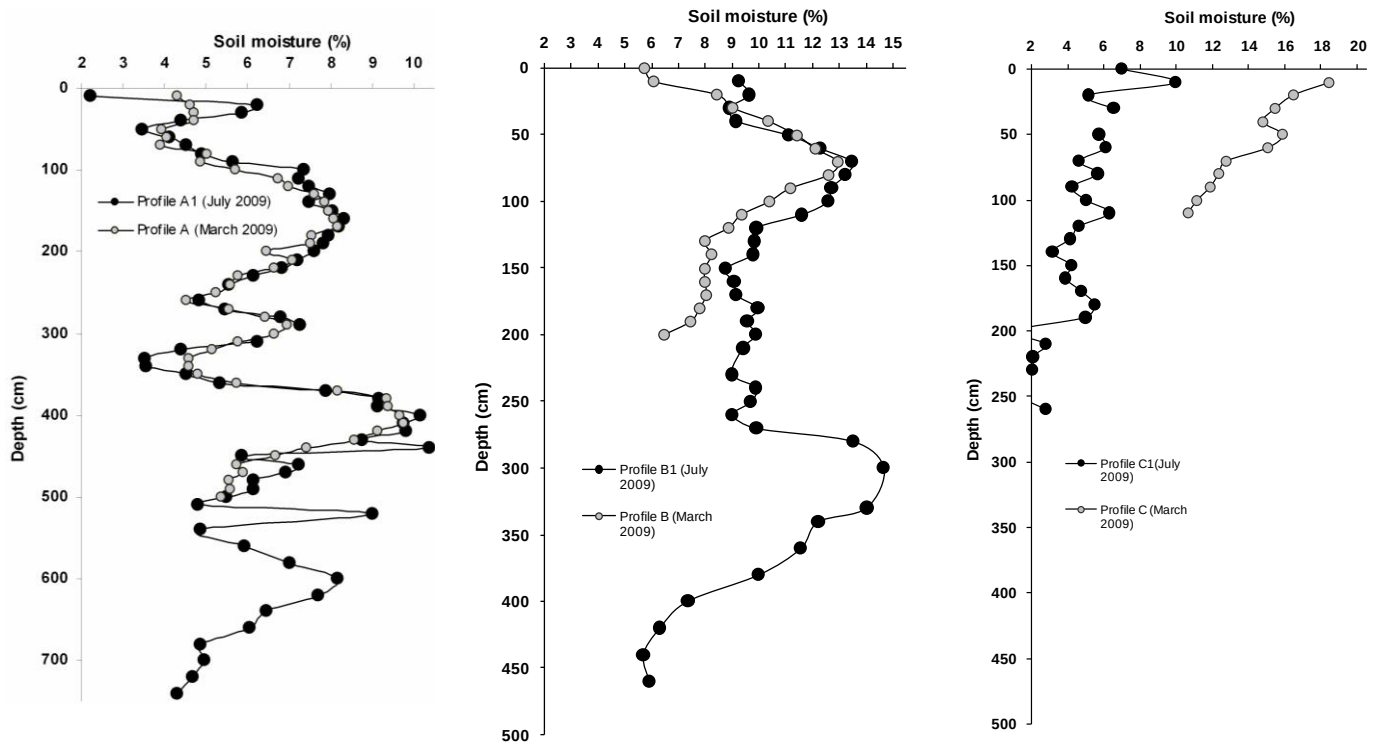


Fig.13: Temporal Variability of the soil moisture in pore water in the selected boreholes

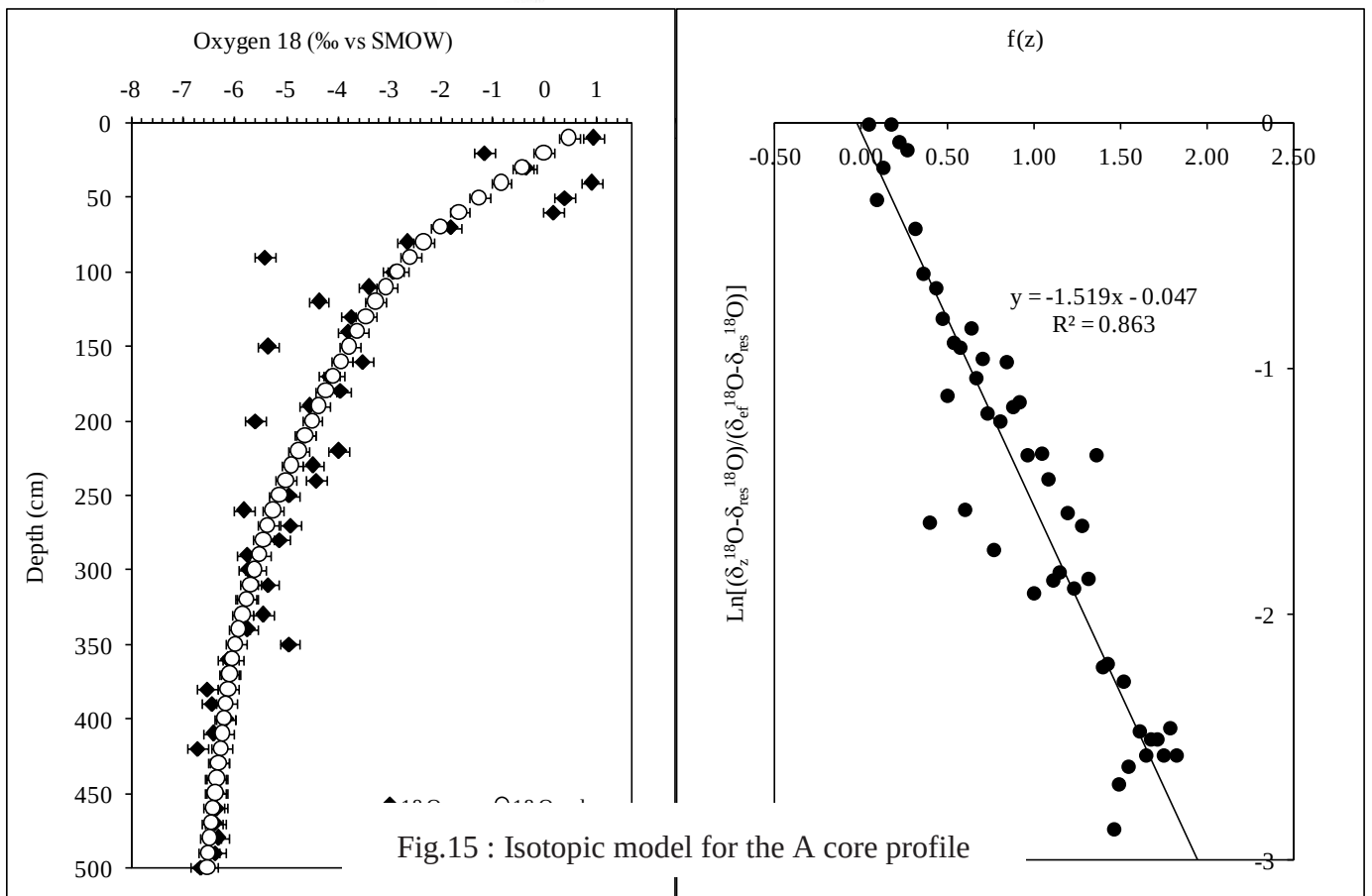
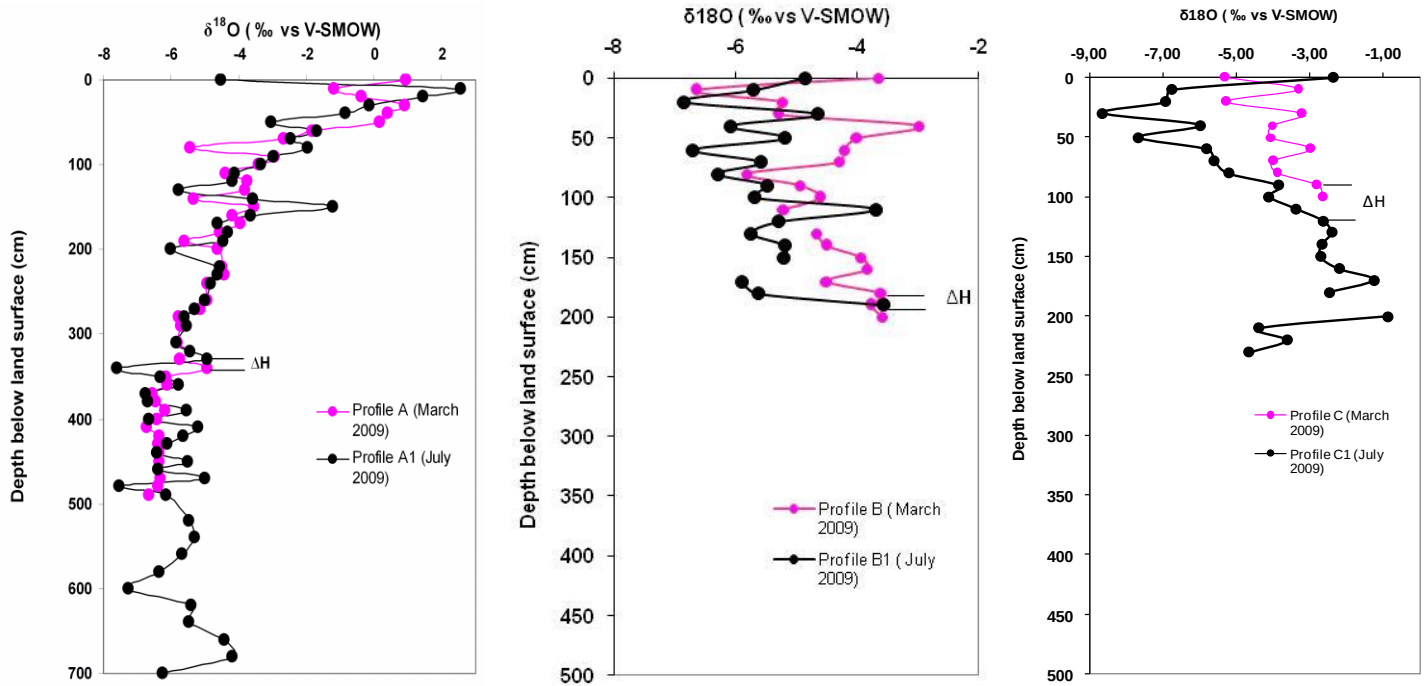


Fig.15 : Isotopic model for the A core profile

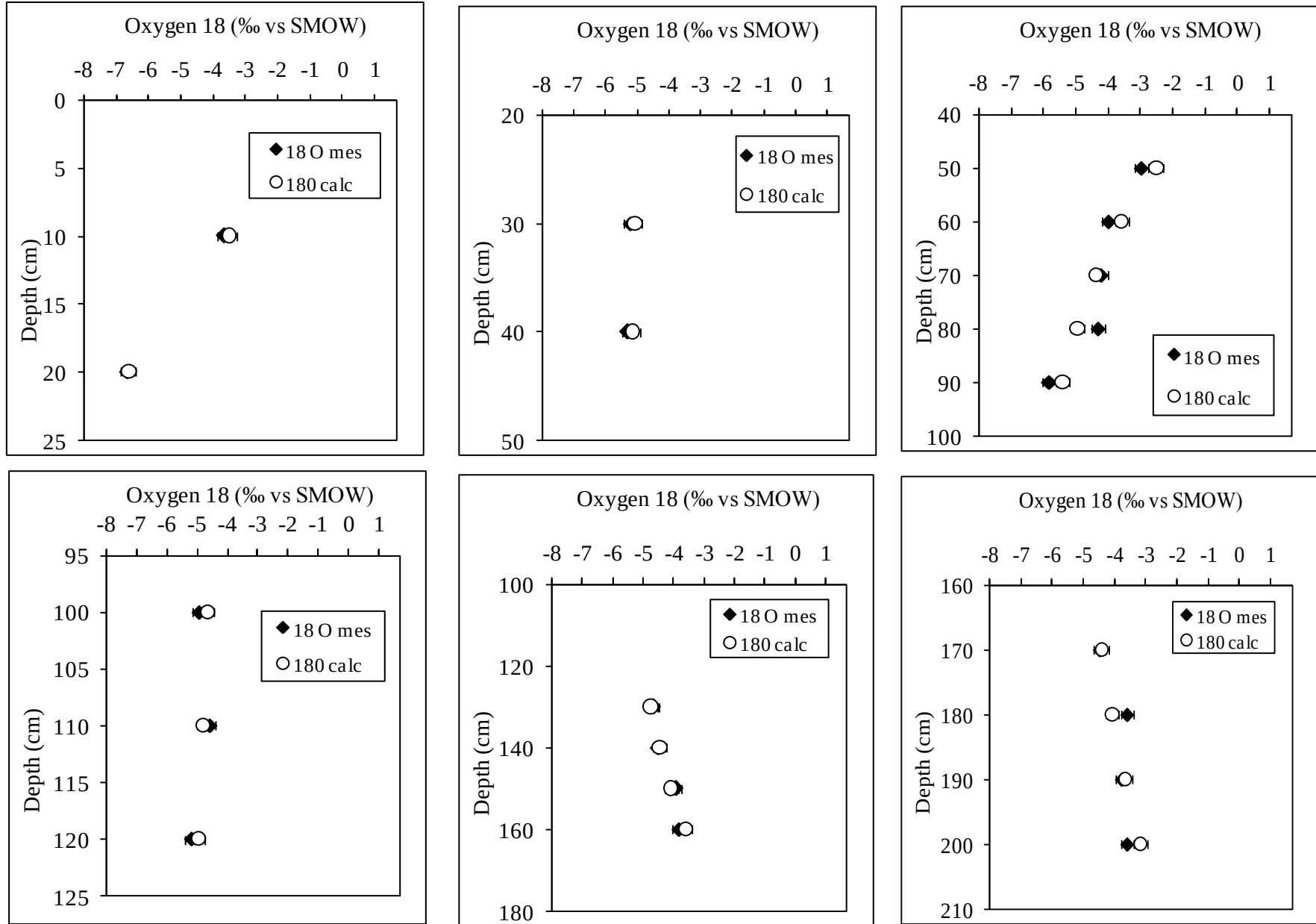


Fig.16: Isotopic model for the B core profile: relationship between $f(z)$ and $\text{Ln}[(\delta z^{18}\text{O} - \delta_{\text{res}}^{18}\text{O})/(\delta_{\text{ef}}^{18}\text{O} - \delta_{\text{res}}^{18}\text{O})]$.

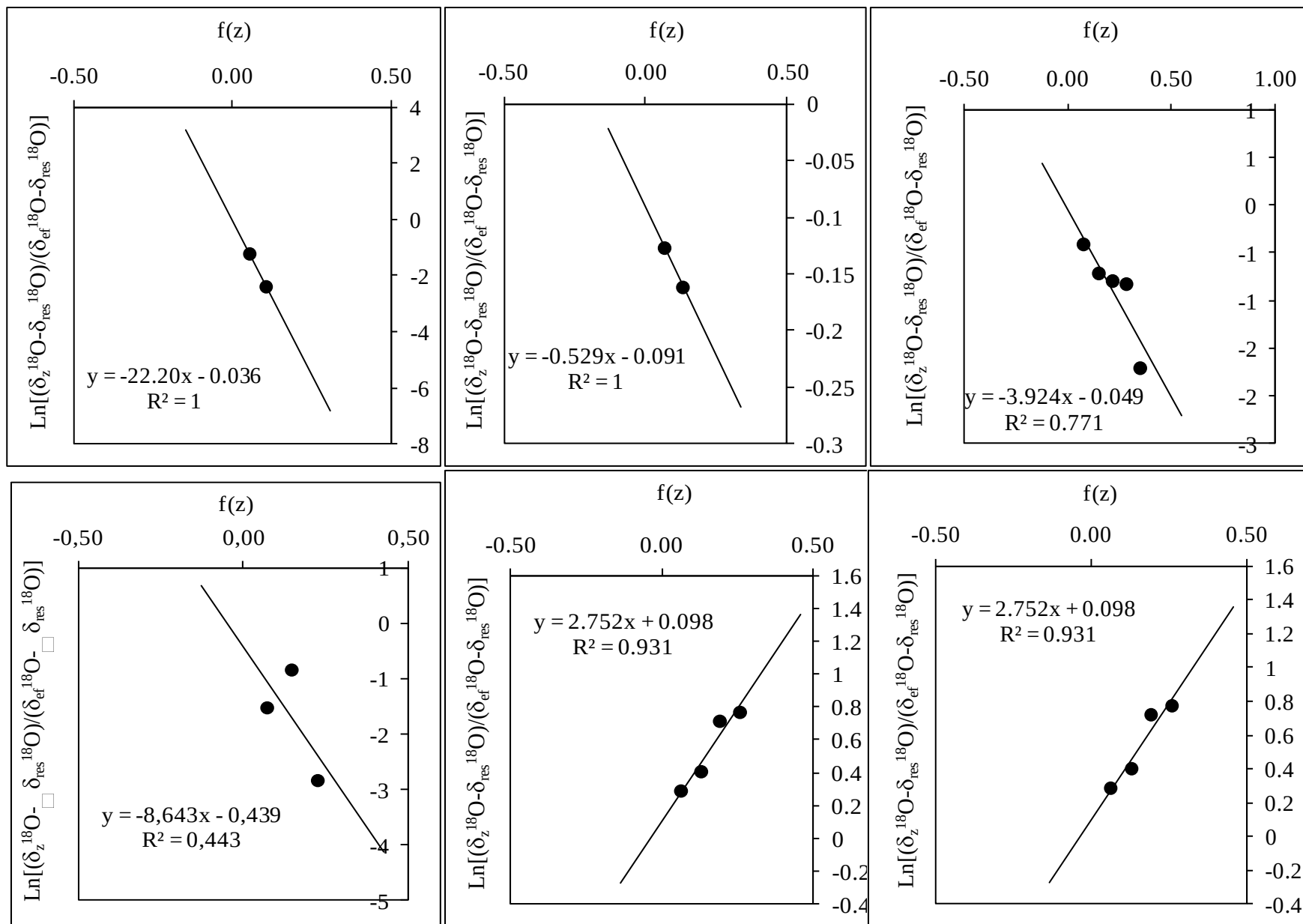


Fig.1 7: Isotopic model for the B core profile: measured and simulated oxygen 18 content (‰ vs SMOW).

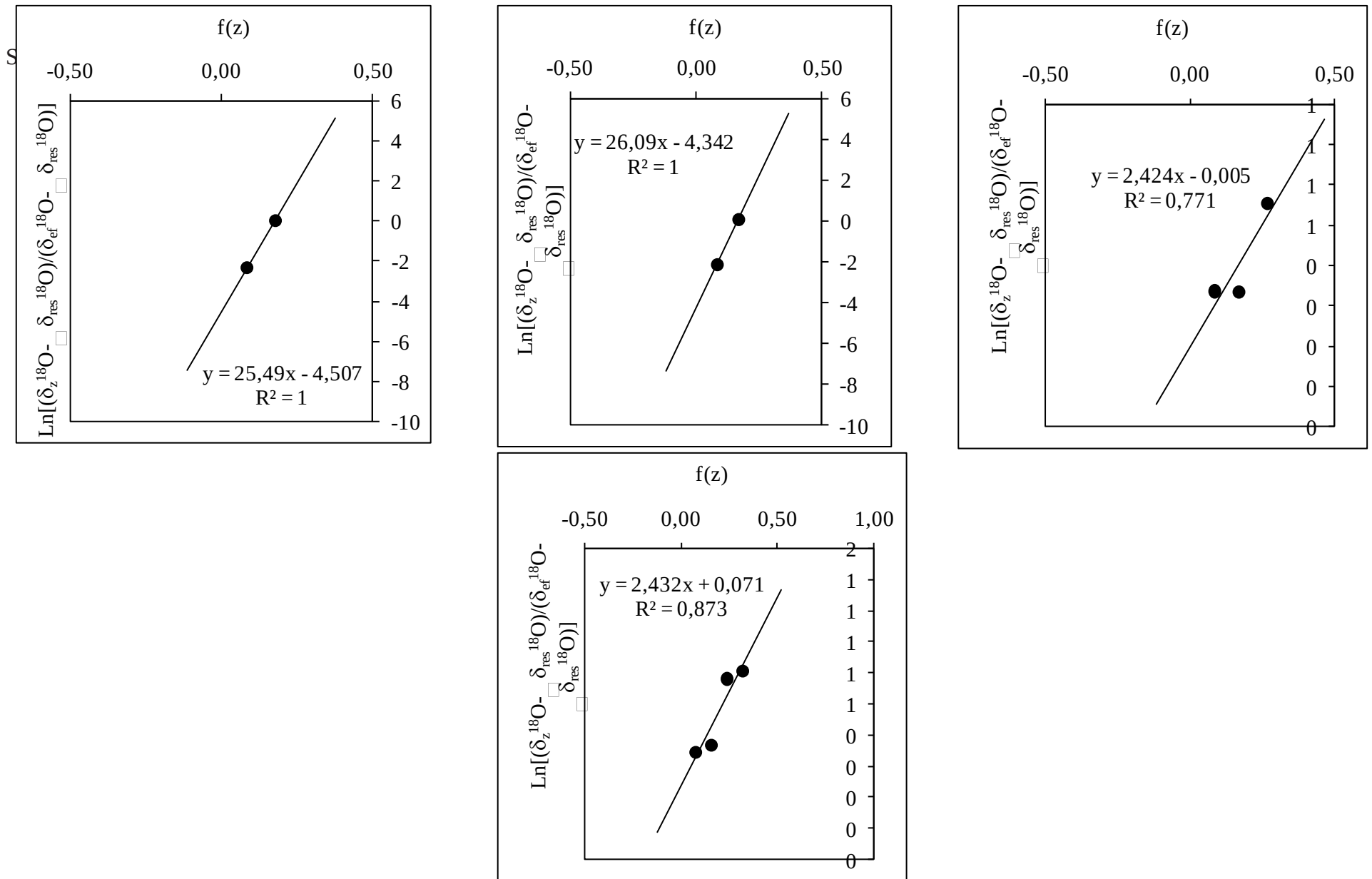


Fig.18: Isotopic model for the C core profile: relationship between $f(z)$ and $\text{Ln}[(\delta_z^{18}\text{O} - \delta_{\text{res}}^{18}\text{O})/(\delta_{\text{ef}}^{18}\text{O} - \delta_{\text{res}}^{18}\text{O})]$.

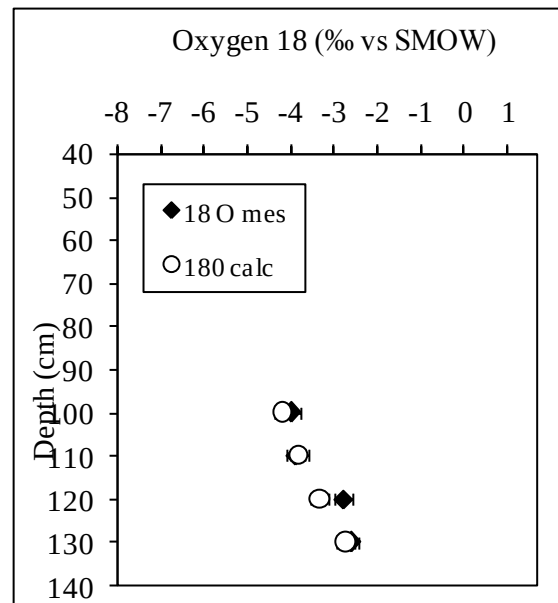
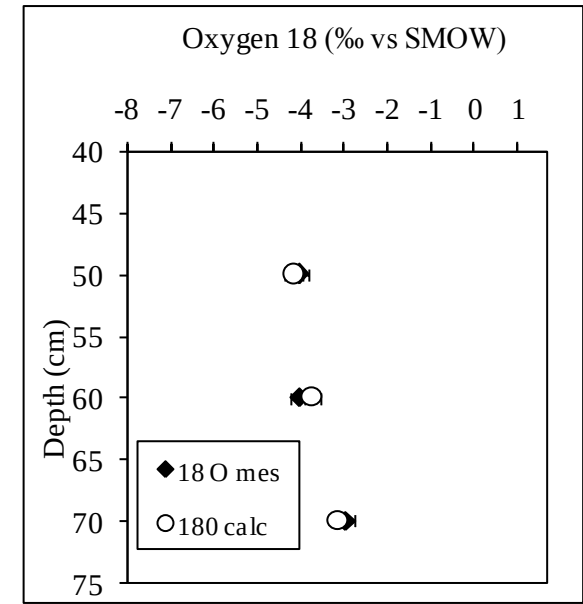
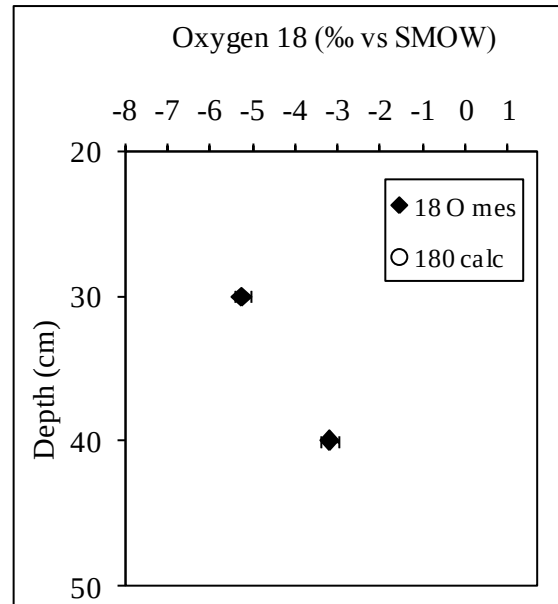
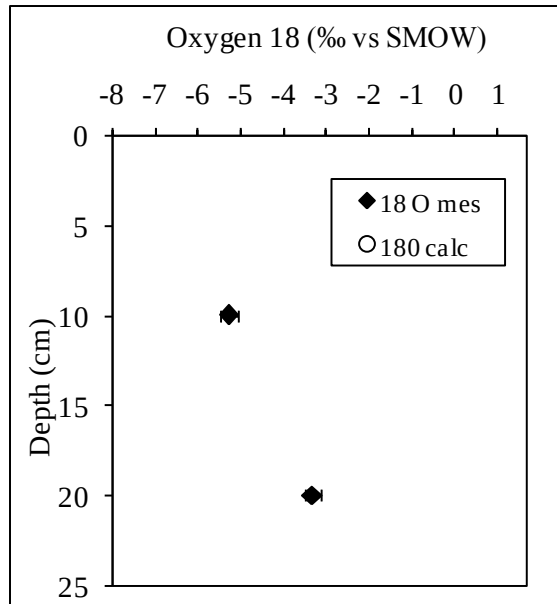


Fig.19: Isotopic model for the C core profile: measured and simulated oxygen 18 content (‰ vs SMOW).

Fluxmeters implementation:

In order to investigate water movement through the unsaturated zone in the irrigated area of Menzel Mhiri, the geochemical and isotopic composition of soil waters at three different depths were monitored from three fluxmeters during two years.

It is important to note that the last two years (2009-2011), are dry with an average annual precipitation of 250 mm. Thus, it appears that we cannot sample if the quantity of the input water is low. Indeed, the minimum water flux that can be measured using lysimeter depends in the surface area of the lysimeter. Scanlon (2002), consider that large lysimeters (surface area 100m²) can resolve a recharge rate of about 1 mm/year. He says also that the lysimeters are more suitable for evaluation of evapotranspiration than recharge. On the other hand, we have always problem in the registration of the data logger. Figure 10 presents tow examples of the registration which indicate that the extraction of samples doesn't registry by the data logger (no pick) (Fig.10 a) or we have registration but we cannot determine the quantity of the flow (Fig. 10b).

Fig.20 a

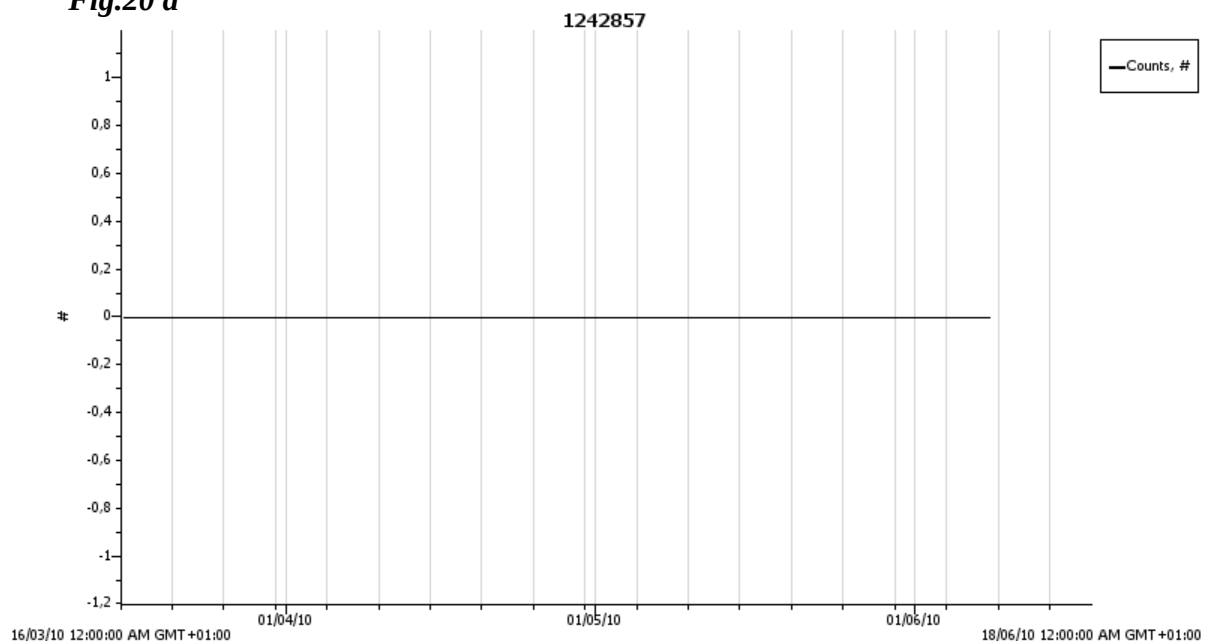


Fig.20 b

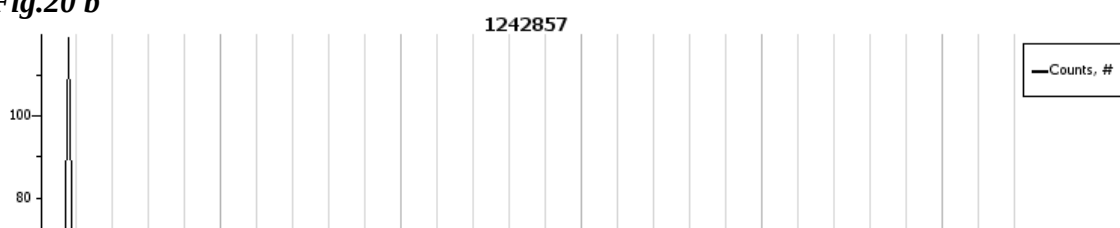


Fig.20: Examples of registration in the data logger

The soil water extracted with fluxmeters are similar to water extracted with cryodistillation suggesting that the $\delta^{18}\text{O}$ seasonal variation in soil water was more pronounced for the profile in the irrigated soils than that of the natural fields.

Most of samples from the lysimeter B and C (irrigated soils) have high conductivity and an enrichment of $\delta^{18}\text{O}$ which confirms that the evaporation is the most important phenomena that control the mineralization of the soil water. Samples from lysimeter A (non-irrigated soil), display lower conductivity confirming that the main origin of evaporated water through the unsaturated zone came from the infiltrated rainfall (the mean value of ^{18}O in the rainfall is about -4‰).

Conclusions

Some comments could be given according to the progress of the project:

- ✓ Chloride profiles are highly disturbed by irrigation water supplies so applying chloride balance will need some precautions.
- ✓ Chloride balance made on natural soil gave an infiltration rate of appreciatively 2 to 4 mm/y.
- ✓ The isotopic model adequately describes the evaporation phases recognized on the oxygen 18 profile. The ratios between the liquid and the vapor fluxes estimated for each of these phases indicate that the water transfer during evaporation mainly takes place in composite liquid-vapor phase.
- ✓ Isotope contents between profile water and fluxmeter water are in good agreement but still need to be discussed

The present project constitutes an appropriate complement of previous attempts to (i) quantify the recharge and evaporation in irrigated areas within selected sites including different type of irrigation practices and different kind of vegetation (culture) and (ii) assess the relative importance of sources of deep percolation and evaporation losses in irrigation basins.

Two specific objectives have been considered for this project:

- At the field scale, quantify spatial and temporal distribution of deep percolation and evaporation in irrigated areas within selected sites including different type of irrigation practices and different kind of vegetation (culture).
- At the basin scale, assess the relative importance of sources of deep percolation and evaporation losses in irrigation basins.

Researches allow to:

- Synthesis of previous studies of the plain of Kairouan
- Typology of soil, vegetation and irrigation practices in the plain through mapping and data collection.
- Implementation of sampling site network in order to monitored the maximum kind of soil, vegetation and irrigations techniques
- Implementation and monitoring of fluxmeters in three different sites under different crops production.
- Realization of 10 core profiles to quantify recharge and evaporation rates
- Analyses of major elements and stables isotopes in cores samples
- Analyses of different water masses (precipitation, lake storage, groundwater and irrigation water, soil water) in order to establish a geochemical framework of the system.

Results confirm that irrigation and fertilization practices have largely influenced the quantity and quality of groundwater recharge. As estimated by CMB method, irrigation waters contribute approximately 100 mm/year to the hydrological system. However, this recharge is very local and generally the long-term irrigation exploitation in many part of the Zeroud basin has caused the generalized decline of water table and not its recharge. Two main groundwater mineralization processes were identified (i) natural process in relation with water-rock interaction such as the dissolution of evaporate and cation exchange (ii) Solutes and nitrate

contamination caused by the return flow of irrigation waters and enhanced by the large application of fertilizers.

Some remarks can be noticed:

- Fluxmeters need long time before water can be extracted.
- Long-term monitoring with fluxmeters seems to be quite delicate given that no registration has been recorded.

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Table 1 : Chemical and isotopic proprieties of lysimeter water samples

Name	Date	Conductivity $\mu\text{S/cm}$	TDS (g/l)	Cl^-	NO_3^-	SO_4^{2-}	HCO_3^-	Na^+	K^+	Mg^{2+}	Ca^{2+}	$\delta^2\text{H}(\text{‰})$	$\delta^{18}\text{O}(\text{‰})$
Lizimeter B	24/10/2009	16,53	14,0505	4236	445,6	3688,8	800	2423,4	0	546,6	910,6	-22,47	-4,38
Lizimeter C	25/5/2009	6,72	5,09376	1646,3	119,8	820,9	341,6	891,8	11,75	132,95	559,05	-14,15	-1,72
Lizimeter C	09/03/2009	8,13	6,16254	1544,2	53,4	2204,45	400	953,05	23,75	191,15	993,45	-14,21	-0,88
Lizimeter B	25/7/2009	3,91	2,96378	761,675	9,825	776,225	150	409,4	30,025	81,8	225,025	-32,71	-5,36
Lizimeter A	24/10/2009	2,99	2,26642	630,025	358,85	16,35	134,2	96,575	58,05	41,1	288,25	-19,12	-3,43
Lizimeter C	15/3/2010	8	6,064	1224,25	130,35	2625,1	200,6	879,55	12,35	208,45	590,25	-11,84	-0,65
Lizimeter B	25/5/2009	35,3	30,005	19817,25	392,5	131,25	120	1722,25	0	320,5	2790,75	-21,00	-2,65
Lizimeter B	25/02/2011	14,28	10	2602,6	0	4670,8	250	1354	44,3	343,2	826,6	-27,53	-3,69

Table 2: Chemical and isotopic proprieties of soil water samples

Sample -site	Depth (cm)	Cl (mg/l)	Soil moisture (%)	Conductivity $\mu\text{S/cm}$	So4 (mg/l)	$\delta^{18}\text{O}(\text{‰})$	$\delta^2\text{H}(\text{‰})$	$\text{NO}_3^-(\text{ mg/l})$
1-A	0	888,33	3,38	398,00	1216,94	0,93	-25,49	70,80
2-A	10	540,79	3,73	439,20	1846,68	-1,18	-31,78	74,60
3-A	20	965,99	4,40	367,71	1218,47	-0,37	-29,01	3162,91
4-A	30	1392,30	4,09	360,29	1174,70	0,90	-25,67	3142,52
5-A	40	1646,24	3,15	342,71	1949,14	0,39	-27,71	1851,41
6-A	50	1678,62	3,04	348,29	2696,33	0,16	-28,49	3306,91
7-A	60	1944,97	3,19	401,42	3818,56	-1,83	-32,18	4441,20
8-A	70	1798,04	3,49	388,00	3066,45	-2,67	-37,19	5829,69
9-A	80	1936,04	5,21	497,29	2293,82	-5,43	-52,95	6750,06
10-A	90	1633,13	5,56	510,00	1961,23	-2,94	-36,52	5988,25
11-A	100	1790,99	6,19	497,00	1820,53	-3,40	-45,83	7019,08
12-A	110	2230,27	6,49	584,29	2186,32	-4,38	-47,81	7599,19
13-A	120	1913,68	7,37	580,00	1757,66	-3,75	-41,38	6455,17
14-A	130	2241,95	7,49	614,61	1306,40	-3,81	-43,26	6796,24
15-A	140	2192,70	7,48	547,00	1023,73	-5,35	-47,03	6256,69
16-A	150	2692,76	7,33	650,71	1604,10	-3,54	-37,04	6957,50
17-A	160	2117,47	7,64	495,00	1313,54	-4,18	-43,25	4754,23
18-A	170	2860,42	7,41	544,86	1422,92	-3,95	-45,78	5882,92
19-A	180	2497,06	6,95	461,00	1081,75	-4,56	-47,44	6072,51
20-A	190	1775,21	6,84	386,00	640,17	-5,60	-53,27	3491,66
21-A	200	2337,86	6,35	377,00	710,19	-4,63	-44,71	4198,66
22-A	210	1453,71	6,05	340,00	552,96	-3,98	-35,81	2557,82
23-A	220	1800,32	5,16	310,90	747,39	-4,49	-36,61	3097,19
24-A	230	1815,97	4,97	333,00	1132,20	-4,44	-41,94	2801,90
25-A	240	2279,01	4,51	272,00	1117,46	-4,94	-39,83	3230,46
26-A	250	2125,39	3,63	282,80	1034,70	-5,82	-45,59	2840,03
27-A	260	2056,12	4,69	269,00	835,67	-4,92	-38,36	2992,76
28-A	270	1809,03	5,76	315,29	650,36	-5,13	-45,06	2364,98
29-A	280	1804,06	6,54	304,00	552,12	-5,76	-47,13	2123,68
30-A	290	1871,45	6,34	337,00	670,58	-5,72	-42,22	1822,92
31-A	300	2079,82	3,76	301,00	853,91	-5,37	-42,13	2370,15
32-A	310	1527,08	4,54	252,00	765,82	-5,80	-41,48	1467,18
33-A	320	1502,83	4,21	280,14	1254,77	-5,45	-43,48	1257,65
34-A	330	1424,42	4,17	278,00	1397,72	-5,75	-43,94	1112,35
35-A	340	1412,42	4,44	269,00	1295,83	-4,94	-41,34	1144,77
36-A	350	1828,84	5,10	257,00	1724,40	-6,13	-44,87	1290,98
37-A	360	1418,35	7,54	329,00	1602,84	-6,12	-43,21	882,55
38-A	370	1088,09	8,89	394,00	2080,49	-6,55	-47,49	775,09
39-A	380	1290,63	9,15	438,00	2743,90	-6,46	-49,03	955,94
40-A	390	1157,06	8,82	443,00	2857,76	-6,18	-45,22	825,29
41-A	400	1139,29	9,30	479,00	3740,26	-6,42	-45,76	732,55
42-A	410	1116,45	8,86	500,00	3129,90	-6,72	-48,54	778,57
43-A	420	1062,75	7,83	452,00	4854,98	-6,33	-40,88	680,24
44-A	430	984,15	6,93	609,00	10052,47	-6,39	-46,43	619,68

Sample -site	Depth (cm)	Cl (mg/l)	Soil moisture (%)	Conductance(μ S/cm)	So4 (mg/l)	$\delta^{18}\text{O}$ (‰)	$\delta^2\text{H}$ (‰)	NO_3^- (mg/l)
45-A	440	988,40	6,60	435,00	5616,79	-6,35	-47,27	639,54
46-A	450	890,13	5,88	511,57	7072,75	-6,35	-47,27	664,00
47-A	460	817,60	5,70	404,00	6609,39	-6,39	-42,45	504,41
48-A	470	944,97	5,36	441,00	8704,72	-6,32	-42,28	478,55
49-A	480	945,72	5,41	469,89	8256,95	-6,39	-40,09	558,22
50-A	490	792,12	5,27	402,00	7358,46	-6,65	-48,79	456,30
51-B	0	129,31	5,21	315,69	643,32	-3,65	-36,74	10,31
52-B	10	189,14	5,55	392,19	917,94	-6,65	-41,33	0,00
53-B	20	433,48	7,93	612,71	5469,20	-5,24	-41,35	0,00
54-B	30	1127,52	8,50	633,29	7506,33	-5,30	-45,28	228,59
55-B	40	1600,15	9,84	658,00	6242,51	-2,99	-35,13	383,58
56-B	50	2216,49	10,94	725,00	6343,01	-4,00	-45,70	254,19
57-B	60	2172,72	11,61	839,00	7262,96	-4,22	-36,36	242,22
58-B	70	2273,14	12,48	1012,57	9220,13	-4,31	-41,91	0,00
59-B	80	1851,61	12,10	1053,00	10159,14	-5,83	-47,97	0,00
60-B	90	2203,92	10,67	834,86	6972,25	-4,95	-34,84	0,00
61-B	100	2320,88	9,91	621,00	5834,33	-4,61	-35,01	0,00
62-B	110	2139,56	8,86	545,00	5454,20	-5,21	-39,96	104,44
63-B	120	1911,65	8,38	499,57	5483,62	-5,40	-39,92	33,39
64-B	130	2303,03	7,49	459,00	5510,71	-4,67	-36,96	0,00
65-B	140	1984,95	7,74	459,64	4634,17	-4,50	-38,93	47,26
66-B	150	1797,37	7,50	404,00	4551,20	-3,95	-33,85	52,06
67-B	160	1681,33	7,50	473,00	4267,12	-3,84	-25,24	50,55
68-B	170	1665,50	7,54	363,00	4044,14	-4,50	-33,47	77,18
69-B	180	1483,28	7,29	332,29	3626,31	-3,60	-33,11	65,42
70-B	190	1593,83	6,95	304,29	3078,04	-3,78	-23,30	81,66
71-B	200	1696,92	5,96	266,00	2775,12	-3,59	-33,13	124,58
72-C	0	1279,82	17,90	1250,23	8052,06	-36,20	-5,29	0,00
73-C	10	1151,79	15,99	2354,22	19876,84	-28,58	-3,32	0,00
74-C	20	972,20	14,95	2201,91	21228,07	-40,03	-5,25	0,00
75-C	30	1750,05	14,26	1168,00	7837,65	-28,52	-3,20	0,00
76-C	40	1245,95	15,36	2853,71	27147,03	-34,28	-4,03	0,00
77-C	50	1350,72	14,57	2340,29	22057,85	-23,89	-4,04	0,00
78-C	60	1440,47	12,24	1806,93	21196,57	-33,26	-2,96	0,00
79-C	70	1290,13	11,86	1409,89	13779,43	-31,87	-3,99	0,00
80-C	80	1586,13	11,34	1567,98	14659,42	-31,30	-3,90	0,00
81-C	90	969,82	10,63	2567,54	37632,43	-32,54	-2,79	0,00
82-C	100	2307,44	10,12	848,00	7193,72	-27,28	-2,63	0,00
83-D	0	540,87	6,44	437,29	3693,90	-3,76	-23,99	0,00
84-D	10	287,75	15,55	1060,00	8658,27	-4,22	-42,60	0,00
85-D	20	990,07	17,11	1872,43	14738,14	-2,43	-21,51	149,33
86-D	30	3335,22	11,26	1340,00	12462,35	-2,38	-22,73	358,09
87-D	40	4225,96	9,95	1294,00	12517,06	-3,44	-23,96	241,66
88-D	50	4036,09	9,14	1335,00	16591,02	-4,60	-43,64	47,38
89-D	60	4855,03	7,71	1063,00	13363,19	-2,90	-35,88	0,00
90-D	70	5310,40	7,25	852,00	8961,63	-2,29	-29,98	0,00
91-D	80	5546,41	9,81	1037,00	6776,81	-2,95	-21,42	0,00
92-D	90	8667,25	7,48	992,00	6558,99	-3,77	-39,74	0,00
93-D	100	9304,24	7,31	977,00	5504,97	-3,70	-35,62	0,00
94-D	110	11386,13	6,63	1042,00	7357,97	-3,19	-34,05	0,00
95-D	120	10864,17	5,76	898,00	5620,24	-5,77	-46,74	0,00
96-D	130	11358,67	4,76	839,86	6420,09	-4,97	-39,22	0,00
97-D	140	12420,38	4,69	850,00	9506,12	-5,29	-45,71	0,00
98-D	150	10615,26	4,06	842,00	12251,32	-3,35	-39,19	0,00
99-D	160	10951,59	4,01	727,00	8666,49	-3,08	-36,75	0,00
100-D	170	9319,85	3,92	762,93	12480,07	-3,77	-44,58	47,61
101-D	180	8793,49	3,12	501,57	6338,54	-5,30	-54,37	0,00
102-D	190	8318,10	2,54	431,04	6515,73	-3,79	-48,26	0,00
103-D	200	9248,49	1,61	295,00	6390,42	-2,48	-35,20	0,00
104-D	210	10404,94	1,75	294,00	7782,38	-3,19	-37,97	0,00
105-D	220	7701,75	1,46	293,00	7467,96	-3,19	-37,97	0,00

Sample -site	Depth (cm)	Cl (mg/l)	Soil moisture (%)	Conductance(µS/cm)	So4 (mg/l)	δ18O(‰)	δ2H(‰)	NO ₃ ⁻ (mg/l)
106-E	0	1146,05	6,14	538,00	2968,12	-2,37	-36,45	794,39
107-E	10	256,60	8,34	430,00	1236,25	-6,77	-50,81	644,75
108-E	20	184,79	8,32	375,00	907,34	-6,91	-51,50	130,90
108-E	30	218,95	7,90	328,00	850,74	-8,65	-63,06	404,36
109-E	40	93,53	8,06	292,00	815,70	-5,99	-40,60	16,85
110-E	50	95,99	8,53	300,00	867,93	-7,66	-50,32	7,25
111-E	60	123,46	8,08	331,00	876,02	-5,80	-41,65	0,00
112-E	70	119,57	7,84	281,00	827,31	-5,59	-36,61	8,51
113-E	80	74,92	7,53	278,00	961,40	-5,22	-33,44	5,16
114-E	90	78,40	6,81	293,00	3113,68	-3,86	-31,70	13,10
115-E	100	103,01	5,92	262,00	1746,15	-4,11	-29,96	0,00
116-E	110	166,10	3,73	276,00	2790,08	-3,39	-33,28	102,67
117-E	120	271,60	2,37	221,00	1633,60	-2,65	-19,73	53,58
118-E	130	226,03	3,21	274,00	1760,35	-2,41	-22,04	65,46
119-E	140	133,92	3,98	246,00	1853,79	-2,68	-30,97	0,00
120-E	150	236,48	3,23	234,00	1446,66	-2,71	-16,94	142,35
121-E	160	218,68	3,48	221,00	1563,43	-2,21	-21,06	64,82
122-E	170	278,79	3,40	250,00	2478,25	-1,26	-15,26	121,05
123-E	180	150,49	4,32	274,00	1731,91	-2,47	-19,15	116,21
124-E	190	128,73	3,99	246,00	1878,72			36,38
125-E	200	275,74	2,74	223,00	1411,86			0,00
126-E	210	282,44	2,82	225,00	1270,52	-0,89	-18,95	255,64
127-E	220	240,84	3,16	209,00	824,52	-4,38	-40,13	53,67
128-E	230	317,93	1,95	217,00	1565,66			0,00
129-E	240	280,98	2,70	230,00	1292,86			68,89
130-E	250	216,33	3,01	253,00	1362,38			88,53
131-E	260	115,07	4,62	212,00	1368,01	-3,62	-30,40	39,32
132-E	270	136,92	5,54	307,00	2189,64	-4,66	-38,44	107,77
133-F	0	142,89	4,53	319,00	338,21	-14,66	2,68	0,42
134-F	10	245,76	5,43	380,00	1068,60	-18,78	0,75	0,99
135-F	20	406,63	5,68	457,00	3337,59	-22,16	0,85	1,10
136-F	30	719,60	5,89	589,00	8668,02	-35,78	-0,92	0,30
137-F	40	2201,25	4,69	539,00	6567,22	-36,71	-0,82	0,05
138-F	50	3391,55	4,06	434,00	5038,81	-25,99	-1,13	2,26
139-F	60	2901,56	4,69	463,00	3152,99	-30,68	-0,08	17,72
140-F	70	2923,56	4,16	416,00	2114,16			30,99
141-F	80	2475,94	5,06	504,00	1397,62	-25,37	0,06	58,92
142-F	90	1682,54	9,37	598,00	605,88	-40,95	-2,63	115,59
143-F	100	1759,28	4,40	385,00	842,32	-23,81	-0,02	44,57
144-F	110	1500,97	3,90	324,00	930,75	-17,60	2,27	25,31
145-F	120	1186,47	3,73	316,00	1101,13	-40,53	-1,54	14,39
146-F	130	828,05	4,07	270,00	1051,29	-34,54	0,03	8,14
147-F	140	625,63	4,16	299,00	1212,73	-25,32	0,15	2,88
148-F	150	516,84	3,91	288,00	1140,59	-31,84	1,35	1,38
149-F	160	333,24	3,81	246,00	869,58	-19,64	0,81	2,48
150-F	170	270,67	3,92	288,00	1010,70	-41,97	-2,14	1,47
151-F	180	292,22	3,67	279,00	1307,99	-25,65	-0,39	2,06
152-F	190	354,80	3,72	244,00	1026,23	-33,43	-0,38	2,95
153-F	200	444,66	3,57	311,00	1227,40			3,55
154-F	210	258,10	3,40	273,00	874,96	-28,03	0,06	2,49
155-F	220	300,67	3,05	248,00	1270,95	-22,92	0,41	2,26
156-F	230	388,29	2,88	274,00	1044,56	-40,71	-1,24	1,86
157-F	240	570,50	2,40	264,00	1628,00	-30,81	-1,79	1,85
158-F	250	454,10	1,83	235,00	1349,96	-35,01	-0,61	0,79
159-F	260	492,56	1,65	245,00	1574,76	-19,81	0,66	0,94
160-F	270	879,48	1,47	223,00	2161,87	-36,25	-1,29	0,48
161-F	280	1043,73	0,91	221,00	2436,70	-6,10	2,89	0,00
162-F	290	953,25	1,19	218,00	2055,69	-19,57	0,48	0,95
163-F	300	1084,66	1,26	238,00	2245,11	-20,33	1,31	1,06
164-F	310	1164,79	0,81	241,00	2785,05			0,00
165-F	320	1691,97	0,66	204,00	5335,76			0,21
166-F	330	1217,20	0,78	208,00	3533,12	-19,50	1,19	0,242
167-F	340	1484,68	0,79	236,00	3078,65			1,12

Sample -site	Depth (cm)	Cl (mg/l)	Soil moisture (%)	Conductance(μ S/cm)	So4 (mg/l)	$\delta^{18}\text{O}(\text{‰})$	$\delta^2\text{H}(\text{‰})$
106-E	0	1146,05	6,14	538,00	2968,12	-2,37	-36,45
107-E	10	256,60	8,34	430,00	1236,25	-6,77	-50,81
108-E	20	184,79	8,32	375,00	907,34	-6,91	-51,50
108-E	30	218,95	7,90	328,00	850,74	-8,65	-63,06
109-E	40	93,53	8,06	292,00	815,70	-5,99	-40,60
110-E	50	95,99	8,53	300,00	867,93	-7,66	-50,32
111-E	60	123,46	8,08	331,00	876,02	-5,80	-41,65
112-E	70	119,57	7,84	281,00	827,31	-5,59	-36,61
113-E	80	74,92	7,53	278,00	961,40	-5,22	-33,44
114-E	90	78,40	6,81	293,00	3113,68	-3,86	-31,70
115-E	100	103,01	5,92	262,00	1746,15	-4,11	-29,96
116-E	110	166,10	3,73	276,00	2790,08	-3,39	-33,28
117-E	120	271,60	2,37	221,00	1633,60	-2,65	-19,73
118-E	130	226,03	3,21	274,00	1760,35	-2,41	-22,04
119-E	140	133,92	3,98	246,00	1853,79	-2,68	-30,97
120-E	150	236,48	3,23	234,00	1446,66	-2,71	-16,94
121-E	160	218,68	3,48	221,00	1563,43	-2,21	-21,06
122-E	170	278,79	3,40	250,00	2478,25	-1,26	-15,26
123-E	180	150,49	4,32	274,00	1731,91	-2,47	-19,15
124-E	190	128,73	3,99	246,00	1878,72		
125-E	200	275,74	2,74	223,00	1411,86		
126-E	210	282,44	2,82	225,00	1270,52	-0,89	-18,95
127-E	220	240,84	3,16	209,00	824,52	-4,38	-40,13
128-E	230	317,93	1,95	217,00	1565,66		
129-E	240	280,98	2,70	230,00	1292,86		
130-E	250	216,33	3,01	253,00	1362,38		
131-E	260	115,07	4,62	212,00	1368,01	-3,62	-30,40
132-E	270	136,92	5,54	307,00	2189,64	-4,66	-38,44
133-F	0	142,89	4,53	319,00	338,21	-14,66	2,68
134-F	10	245,76	5,43	380,00	1068,60	-18,78	0,75
135-F	20	406,63	5,68	457,00	3337,59	-22,16	0,85
136-F	30	719,60	5,89	589,00	8668,02	-35,78	-0,92
137-F	40	2201,25	4,69	539,00	6567,22	-36,71	-0,82
138-F	50	3391,55	4,06	434,00	5038,81	-25,99	-1,13
139-F	60	2901,56	4,69	463,00	3152,99	-30,68	-0,08
140-F	70	2923,56	4,16	416,00	2114,16		
141-F	80	2475,94	5,06	504,00	1397,62	-25,37	0,06
142-F	90	1682,54	9,37	598,00	605,88	-40,95	-2,63
143-F	100	1759,28	4,40	385,00	842,32	-23,81	-0,02
144-F	110	1500,97	3,90	324,00	930,75	-17,60	2,27
145-F	120	1186,47	3,73	316,00	1101,13	-40,53	-1,54
146-F	130	828,05	4,07	270,00	1051,29	-34,54	0,03
147-F	140	625,63	4,16	299,00	1212,73	-25,32	0,15
148-F	150	516,84	3,91	288,00	1140,59	-31,84	1,35
149-F	160	333,24	3,81	246,00	869,58	-19,64	0,81
150-F	170	270,67	3,92	288,00	1010,70	-41,97	-2,14
151-F	180	292,22	3,67	279,00	1307,99	-25,65	-0,39
152-F	190	354,80	3,72	244,00	1026,23	-33,43	-0,38
153-F	200	444,66	3,57	311,00	1227,40		
154-F	210	258,10	3,40	273,00	874,96	-28,03	0,06
155-F	220	300,67	3,05	248,00	1270,95	-22,92	0,41
156-F	230	388,29	2,88	274,00	1044,56	-40,71	-1,24
157-F	240	570,50	2,40	264,00	1628,00	-30,81	-1,79
158-F	250	454,10	1,83	235,00	1349,96	-35,01	-0,61
159-F	260	492,56	1,65	245,00	1574,76	-19,81	0,66
160-F	270	879,48	1,47	223,00	2161,87	-36,25	-1,29
161-F	280	1043,73	0,91	221,00	2436,70	-6,10	2,89
162-F	290	953,25	1,19	218,00	2055,69	-19,57	0,48
163-F	300	1084,66	1,26	238,00	2245,11	-20,33	1,31
164-F	310	1164,79	0,81	241,00	2785,05		
165-F	320	1691,97	0,66	204,00	5335,76		
166-F	330	1217,20	0,78	208,00	3533,12	-19,50	1,19
167-F	340	1484,68	0,79	236,00	3078,65		

Sample -site	Depth (cm)	Cl (mg/l)	Soil moisture (%)	Conductance(μ S/cm)	So4 (mg/l)	$\delta^{18}\text{O}$ (‰)	$\delta^2\text{H}$ (‰)	NO_3^- (mg/l)
168-G	0	2370,31	4,18	502,00	6005,69	-0,70	-37,04	444,12
169-G	10	928,27	5,50	459,00	9904,85	-2,21	-28,34	355,82
170-G	20	455,40	6,54	441,00	7796,43	-4,29	-32,95	353,38
171-G	30	529,51	7,29	680,29	13807,38	1,58	-6,36	555,64
172-G	40	1618,75	7,78	928,14	15083,94	0,46	-27,06	685,08
173-G	50	2448,50	7,55	899,57	15326,59	1,97	-17,80	650,13
174-G	60	4487,85	7,47	1059,86	17297,25	0,92	-16,77	436,21
175-G	70	6870,58	6,46	952,00	15464,53	0,73	-20,06	1114,11
176-G	80	8401,05	5,92	805,00	8738,47	-1,14	-23,76	2071,87
177-G	90	7759,26	5,94	697,00	5488,89	-0,95	-14,49	2337,29
178-G	100	8392,29	6,63	894,00	4676,97	-1,39	-12,95	2924,98
179-G	110	8286,50	6,52	808,00	4084,83	-1,49	-21,76	3484,73
180-G	120	8095,37	6,73	745,00	2758,77	-0,92	-23,98	3904,85
181-G	130	7843,27	6,55	745,00	2508,47	-2,24	-24,67	4211,83
182-G	140	6473,36	6,80	624,00	821,26	-1,39	-14,89	4140,91
183-G	150	6747,90	7,00	690,00	937,71	-1,39	-23,45	4614,84
184-G	160	4565,30	7,24	588,00	712,37	-1,38	-18,72	3400,71
185-G	170	5150,48	5,00	455,00	1272,49	-2,15	-32,25	3837,11
186-G	180	6187,50	2,29	318,00	2219,26	-0,68	-10,77	4622,95
187-G	190	6236,01	1,79	275,00	1939,96	-0,21	-20,05	4710,66
188-G	200	10661,89	0,62	224,00	3985,16	-1,54	-19,79	9388,58
189-G	210	8102,89	1,00	247,00	6580,20	1,02	-17,21	4811,40
190-G	220	8360,75	0,98	271,00	3434,03	2,29	-12,70	5348,67
191-G	230	5587,89	1,20	246,00	3437,42	1,85	-15,01	4893,89
192-G	240	3940,49	1,29	203,00	2451,70	1,77	-8,29	3063,35
193-G	250	8786,01	0,56	191,00	3999,41	1,51	-6,32	5498,08
194-G	260	5582,81	0,70	202,00	3385,66	1,01	-11,46	3020,14
195-G	270	4488,62	1,00	204,00	2748,57	1,52	-3,62	2401,08
196-G	280	4415,37	1,04	189,00	2068,74	1,70	-9,33	2960,21
197-G	290		1,00			0,41	-10,95	0,00
198-G	300		1,00			-2,12	-26,00	0,00
199-G	310	4613,73	4,34	443,00	3497,50	-1,52	-18,52	2126,03
200-G	320	6949,03	3,50	474,00	5767,94	-4,14	-35,35	2911,36
201-G	330	2935,44	4,34	302,00	2302,55	-3,27	-35,00	1353,36
202-G	340	3091,26	6,99	412,00	2456,29	-1,75	-24,54	1357,61
203-G	350	1989,26	5,00	283,00	2033,13	-0,53	-15,44	774,69
204-G	360	4063,56	1,82	223,00	3352,16	0,91	-18,36	1988,37
205-G	370	4347,57	2,00	256,00	4532,50	0,51	-15,89	2068,94
206-G	380	2791,07	2,66	237,00	2012,86			1524,81
207-G	390	4130,81	2,00	236,00	2933,79	0,48	-17,23	1811,69
208-G	400	4464,66	1,70	228,00	3811,34			2088,20
209-G	410	5302,08	1,30	225,00	3930,03	0,68	-19,11	2461,17
210-G	420	5404,35	1,40	225,00	4027,34	0,67	-20,46	2323,67
211-G	430	4049,82	1,35	228,29	2857,71	1,12	-22,35	2188,70
212-G	440	2836,41	2,18	201,00	3647,46	-1,09	-20,27	1367,68
213-G	450	2685,75	4,54	308,00	2336,48	-1,64	-25,91	1129,50
214-G	460	3692,86	4,00	367,00	4252,00	-1,09	-25,74	1439,84
215-G	470	2949,80	3,50	291,00	2590,80	-1,12	-26,13	876,31
216-G	480	2201,84	3,20	232,00	2842,49			961,45
217-G	480	3177,53	3,00	633,00	12908,54	-2,12	-27,55	4417,60