Project RAF/8/035

The Use of Environmental Isotopes for Evaluation of Water Resources of the North Western Sahara Aquifer System

Second Coordination Meeting and Technical Workshop

Sousse, Tunisia
5 – 9 July 2004

MEETING REPORT

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1. INTRODUCTION

The third co-ordination meeting of the regional project RAF/8/035 on "The use of environmental isotopes for the evaluation of water resources in the North - Western Sahara Aquifer system" (NWSAS) has been held in Vienna (Austria) from 5 to 9 December 2005 in the premises of the IAEA. The meeting was attended by representatives of Algeria, Libya and Tunisia, the three countries sharing this important groundwater reservoir and participating in the regional project, by IAEA staff of the Africa Section and the Isotope Hydrology Section (cf. List of participants in Annex I).

2. CONDUCT OF THE MEETING

The meeting was opened by the inaugural speech given by Mr. Ali Boussaha (Director, Africa Division, IAEA) who emphasized on the main objective of the meeting which is the assessment of the technical progress achieved so far. He confirmed the availability of the Agency in supporting member states in the implementation of the isotope methodology and its added value for the National programmes. He added that another objective is the set up of a working plan for year 2006 and further, and also to evaluate the input of the IAEA and decide on the nature of future support from the Agency.
The participants were afterwards invited to present themselves before Mr. Andy Garner, acting head of the isotope hydrology section took over to welcome the country delegates and wish them a successful meeting and a nice stay in Vienna.
In his opening address, Mr. Cheikh Gaye presented a brief review of the overall objectives of the project and the Agenda of the meeting, which was then adopted by the participants (Annex II). Prof. Zouari (Tunisia) was designated to chair the meeting and Messieurs Ramzy (Libya), Abidi (Tunisia) and Moulla (Algeria) were appointed rapporteurs of the meeting.

The meeting proceeded with presentations of progress reports by the representatives of, Algeria, Libya and Tunisia on the achievements made so far in the implementation of the national projects and especially since the second co-ordination meeting held in Sousse (Tunisia, 5 – 9 July 2004). The data gathered are compiled in a single common database that was to be updated before the end of the meeting making use of all the new results. The data were technically assessed and substantive efforts were done at each national level with regard to the interpretation of the chemical and isotopic results.

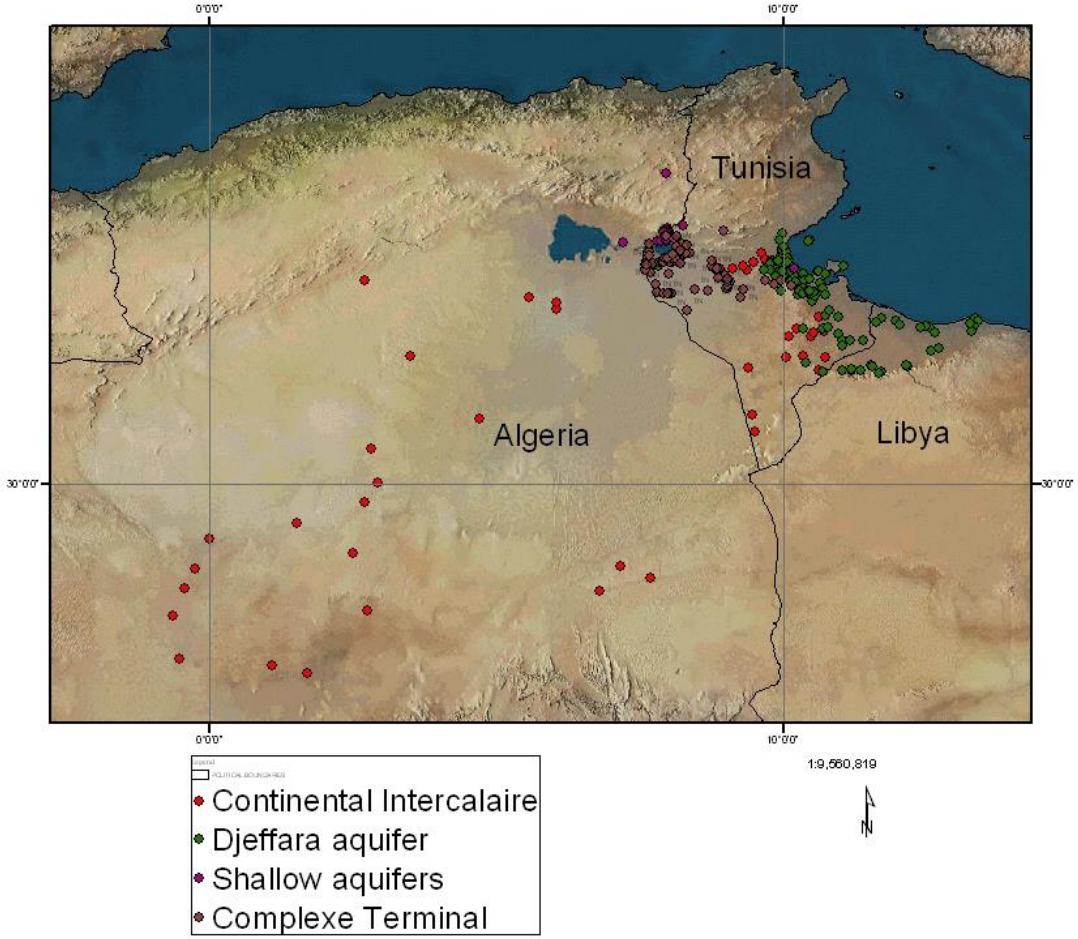


Fig. 1: Map of Location of the sampling sites in the NWSAS in Algeria, Libya and Tunisia

3. ACHIEVEMENTS OF THE NATIONAL PROJECTS

3.1 ALGERIA'S NATIONAL PROJECT COMPONENT

Review of the objectives of the project

The main objective of the project is to gather essential and updated information that would be usable by water managers of the three involved countries to develop and establish appropriate models that should be able to facilitate the implementation of a trans-boundary integrated management of the shared resources. A synthesis of the existing data propped-up by a better characterization of the present behavior of the aquifers under investigation and an up-to-date knowledge of their hydrodynamics and their vulnerabilities to various constraints is required. Specific objectives for Algeria are:

- To better characterise recharge areas and evaluate infiltration rates from the Saharan Atlas southern foothills.
- To contribute towards a better knowledge of the western sub-basin and especially the Foggara system (CI discharge area in that region).
- To clarify CI to CT upward leakage and the contribution of Amguid El-Biod faults to that phenomenon for which not much evidence exists to fully support this hypothesis.
- To estimate the evaporative losses in the discharge zones and evaluate the risk of salinisation in the Chotts discharge areas due to overexploitation and drawdown of water table especially for the CT.

These once implemented will enable a better determination of the water budget and also of the vulnerability of the system to salinisation and will contribute to a better evaluation of the volumes of water that can be extracted without negatively impacting on the aquifer (over-exploitation).

Fieldtrip and analytical work achieved

In accordance with the conclusions and recommendations of the two previous coordination meetings, the Algerian team has effected in total six sampling campaigns.

Let us remind that the two first missions that were performed in the framework of this project took place in the Saoura valley at the border of the Great Occidental Erg. These were followed by another campaign on the recharge area in the southern foothills of Atlas mountains (around Laghouat and Ghardaia).

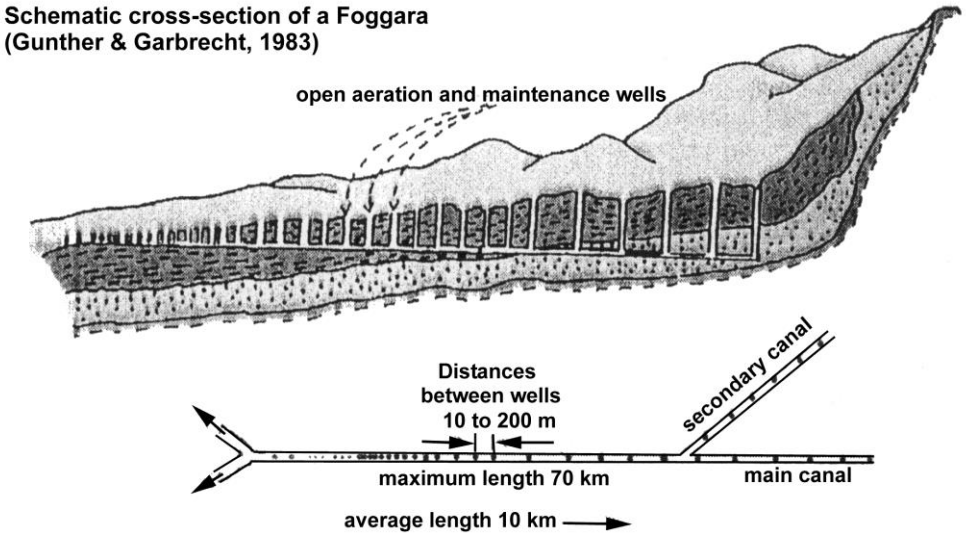
Three other campaigns were carried out since the last coordination meeting in Sousse. Two of them concerned the Occidental sub-basin with one in the Tidikelt region around In-Salah (30 samples, Cherchali). A link with previous results from project RAF/8/022 is to be made for this area.

Another campaign that has a regional importance was performed afterwards around the triple boundary point in Ghadames basin.

The whole set of gathered samples (173) was analysed for chemistry. The majority of samples (133) were also measured for stable isotopes. There remain the last ten samples from Ghadames basin and those from the Tidikelt (30). The same remark is valid regarding tritium (24 remaining).There are also some radiocarbon measurements which have been performed (29).

In the Great Occidental Erg, the research team spent two weeks and covered ~8400 km to visit and sample 55 sites in four different provinces. Among these, 36 were boreholes including the unique artesian borehole but also the only spring of the region, 05 dug wells, and 09 Foggaras. The latter constitute the discharge points for the CI aquifer in the Great Occidental Erg.

The Foggara is a very ancient ingenious traditional way used by farmers (gathered in associations) to tap groundwater and convey it naturally towards their gardens and palm groves. It is an underground sub-horizontally dug gallery that is provided with an adequate slope allowing groundwater to flow by gravity.



Due to the proliferation of boreholes drilled in the framework of agricultural development programmes in the upstream areas, there was a drawdown of piezometric levels and many of these Foggaras dried out. This means no more agricultural activities downstream with the known socio-cultural consequences on the autochthonous populations.

UNESCO based upon long local contestation and protest and in order to protect this traditional irrigation system, reacted and classified it as a *universal heritage*. One of the objectives of this study aims thus at gathering essential knowledge on the system that should contribute as much as possible for the cause.

In the Great oriental basin, six day fieldtrip was effected around the three-countries boundary common point in Ghadames basin. About 4250 km were covered in an isolated region under harsh conditions such as temperatures ranging between 26°C early in the morning and 44°C at mid-day. Eight deep piezometers (~800m deep) tapping either the Barremian only or the Albo-barremian aquifer system (CI) were bored in the region and the Ministry of Water Resources has planned for more survey sites. Ten locations including 03 piezometers and 07 boreholes were visited and sampled.

Remaining work for 2006 and later

It is foreseen a fieldtrip to the western part of the Saharan Atlas southern foothills, which is the recharge area for the Great Occidental Erg groundwaters. It is also a region which is completely free from isotopic studies.

It is also expected to tackle the question of upward leakage from the CI to the CT aquifer in the faulted region of Amguid El-Biod in the north western part of Tinrhert plateau. The precious co-operation of any national institution such as the national oil company or the Algerian geological survey (ORGM) which may have knowledge and data on that region would be sought.

At the regional scale, it would be good to address the question of the hydrodynamics of the shared resources in the vicinity of the borders three countries that are involved in the project. The Algerian part is planning to launch another piezometer drilling programme near the borders. Moreover, the common validation of the water budget parameters used in the SASS model is requested.

The study of the gradient inversion near the Chotts is on-going at the OSS. The first results show that this inversion is already effective with a drawdown of ~100m for the phreatic groundwaters and 10-20m for the CT aquifer. The updated geologic map has been drawn by ANRH based on an inventory of 11.000 water points. In addition, the drilling of 23 observation wells is planned. The investigation making use of isotope methods will be implemented.

SWOT analysis

Strengths:

- The project allowed the initiation and establishment of strong collaboration among stakeholders at national levels and support of IAEA is felt as strong catalyst enabling increased awareness of the value of isotopes use (simple and cost effective) in the Water sector.
- Also, the project allowed the reinforcement of regional co-operation and the introduction of a regional integrated shared resources management concept that is to be implemented with all the benefits that might be inferred.

Weaknesses:

- Poor communication between different regional counterparts, that should be improved for the sake of the efficient implementation of the project results.
- Lack of sustainable analytical facilities for stable isotopes in the three countries
- Delays in provision of equipment and consumables. Delays in stable isotope analyses and capacity building files treatment by IAEA.

Opportunities:

- The commitment from IAEA is very important. This is traduced by capacity building activities through individual and group trainings, scientific visits, experts' missions, consultancy services, provisions of equipment and consumables, assistance with isotope analyses, support for co-ordination meetings, etc. These supported activities are seen as major opportunities for the counterparts' teams and laboratories.

Threats:

- Discontinuity and/or difficulty in maintaining medium and long term momentum for sustainable use of the isotope methodology. This could be caused by many factors among which: withdrawal of external support (such as presently that of IAEA) for such projects and frequent changes in decision-makers poles (bosses' waltz) at counterpart levels.

Water Management policy in relation with the project

The national water resources management policy in relation with the areas investigated within the frame work of this project consists of planning to exploit the deep CI and CT aquifers for the drinking and irrigation water supply programmes of the High Plateaus and the steppe areas.

The first region which would be targeted is the one located north of the central Saharan Atlas in the province of Laghouat. Water abstraction is expected to reach the rate of 3.5 m^3/s by year 2010. The Ministry of Water resources intends also to take benefit from the groundwaters occurring in the south western part of the Saharan Atlas around Mehaguene in the west of Laghouat (2.3 m^3/s). Moreover, water resources managers at high level decided to plan for a huge water transfer programme for Tamanrasset on a 743 km distance from the Tidikelt region around In-Salah at a rate of 1m^3/s (31.5 Mm^3/annum) with an ascending slope of ~800m from the CI aquifer.

23 piezometers are to be implemented in the vicinity of the Chotts region (CT discharge area) in order to better survey the fluctuation of the CT aquifer water table and better assess the question of gradient inversion. Six reconnaissance boreholes are presently being drilled in the same region to tap the Senonian carbonates aquifer and allow a better characterization of the aquifer hydrodynamic patterns.

About fifteen deep piezometers are planned in the region of Ghardaia to follow the artesianism evolution of the Albian formation aquifer which has noticeably decreased since the past five years. In the eastern su-basin, the piezometric network of the El-Oued region would be enriched by the implementation of about twenty new piezometers. The latter will serve the surveillance of the phreatic aquifer which is suffering severe rise of its water table due to return of irrigation flows from deeper CT aquifer.

Still in the same sub-basin, 53 piezometers are planned to reinforce the local network around the city of Ouargla and are intended to better survey the behavior of the CT aquifer in that area. Near the triple boundary point of Ghadames another 8 piezometers whose location will be determined following the results of this project in that area, would be bored.

On the occidental sub-basin50 piezometers are to be drilled in the province of Adrar during the first half of next year for the surveillance of the CI and prevent more damage to be done to the Foggara traditional irrigation system in the Touat-Gourara region.

Finally, regarding the question of upward leakage from CI to CT favored by the Amguid El-Biod faulted area in the north west of Illizi that need further clarification, two or three reconnaissance boreholes will be drilled in addition to the 15 piezometers that are intended to be to survey the behavior of the CI aquifer in that province.

3.2 LIBYA'S NATIONAL PROJECT COMPONENT

Review of the main of objectives of the project:

The national component of the regional project in Libya aimed at isotopic investigations in four areas: the Jefara plain, the Ghadames area, the eastern part of Alhamada basin, and Jabal Nafusa area. So far, only the studies in Jefara plain have been started with the following main objectives:

- Identification of the sources and mechanisms of recharge
- Determination of relationships between the three main aquifers
- Study of seawater encroachment risks.

Activities carried

After investigation of the existing hydrogeological and geological information (maps etc) a network of sampling sites has been established under assistance of partners from Tunisia and Algeria. This was followed by two sampling campaigns (April 2003 and June 2003) during which 30 samples were collected from the different aquifers. The analyses performed on these

samples include: chemical and stable isotope analyses (30 samples), tritium (30), 14C and 13C (27).

The study area (Jifarah plain) is located in the north-west of Libya. It is a triangular area of about 20,000km² (about 1% of the land surface), which is limited in the north by the Mediterranean Sea, in the south and the east by Jabel Nafusa (which reaches the sea near the town of Al Khoms), and in the west by the Tunisian border. The Jifarah plain is a very important part of the country, where more than 45% of the Libyan population lives and from which more than 50% of the agricultural products, especially fruits, comes (in addition to some minor industrial products).

Aziziah aquifer (middle Triassic) consists of Dolomitic limestone. It forms another aquifer well developed in the south-central and southwestern part of the plain. The Aziziah formation is outcropping along the foothills of Jabel Nafusa where the tertiary formations are absent.

Major findings

- The chemistry of the analysed groundwater appears to be dominated by dissolution of evaporates, in particular of halite and gypsum. The TDS (EC) ranges from 400 mg/l up to 14000 mg/l, one samples shows a TDS value of about 40000 mg/l, indicating dominance of seawater. A correlation between chemistry and the aquifers will be subject of follow up.
- The 18O values range from -8.1 to -4.7 %, these values plot around the MWL in the 2H – 18O diagram. Two exceptions are represented by the samples with remarkable contribution of seawater (18O -4.17 and +1.18 permil). Three groups can be distinguished on the basis of this diagram the first group clusters around -8 permil, the second around -6 and the third around -5 permil. This grouping is suggested to reflect the different aquifers, but needs to be confirmed by detailed hydrogeological investigations. Comparing the data with the WMWL it seems that the first group represents palaeowater. The other two groups are clustered around the WMWL which appears to indicate that evaporation during infiltration of the groundwater does not play a major role (in distinction to some sites in Tunisia).
- Tritium ranges between 0 and 2.2 TU. Groundwater below about 200 m is practically free of tritium (one sample at 950m with 0.36 TU has to be considered as an outlier). The two highest tritium values correspond with high 14C and therefore indicate contribution of modern recharge. A further discussion of this finding will be made consulting the hydrogeology of the respective sites.
- The measured 14C values range from 1.9 to 59.1 pmC. The data support the finding based on 18O, namely the identification of three groups of groundwater. The first group at about -8 permil corresponds with 14C values from 5 to 50 pmC. The second group (18O around -6 permil) corresponds with relatively low 14C values (about 2 to 10 pmC) and the third group (18O around -5 permil) represents relatively young groundwater indicated by correspondingly high 14C values. One sample has been found with low 14C values at rather shallow depth. This sample is characterized by a relatively high mineralization (TDS at about 5000 mg/l). This finding would be consistent with a discharge of deep groundwater through a fault (system). This suggestion has to be further discussed including geology and hydrogeology of the respective site.

Activities to be carried out in 2005-2006:

- Complement for Djeffara plain sampling and analysis
- Refine the tentative interpretation of isotope and geochemical data using necessary geological and hydrogeological information (to be terminated in 2004)
- Initiate at the beginning of 2005 investigations (including sampling, analysis, interpretation/evaluation) for the remaining areas with Djebel Nafusa as a first priority.

Requested input from IAEA:

(1) Equipment

- PH-meter with iron selective electrodes ; F,CL,SQ,CN,S,NO3.
- Portable conductivity meter with prop.
- Solar pumps (2) units.
- Rain gauges (5) units.

- **Note**: for the heavy elements; Tajoura nuclear research center (TNRC) will check the installation, the lines , the components, then the performance of the existing (AAS), further (TNRC) will train some selected laboratory staff, and possibly (TNRC) will take part of the analyses.

- Ammonium Pyrolidine Dithiocarbomate (APDC)***** pure. 100g x 6.
- Methyl Isobuthyl Ketone (MiBK)***** pure. 2.5 Liter x 10.
- Reference Standard for Heavy Elements in water*****.
- Sodium Borohydrite*****, pure. 100g x 10
- Thin chloride*****, pure. 100g x 10

<u>Important note:</u> The items market with (*) above, are urgently needed in order to conduct the remaining work, so your prompt action is greatly appreciated.

(2) Training

About 3-6 months training for 3 persons are requested.
A National workshop for data interpretation practice will be held during the last quarter of 2004
Scientific visits will be requested for senior scientists (two man-months).

(3) Expert services

One to two expert missions will be requested to assist in evaluating the progress of the project during 2005.

(4) Analytical services

The table below summarizes the analytical needs

Area/Aquifer		ANALYSES (samples)					
				Chemical	Stable isotopes	Radioactive isotopes C14 H3 Cl 36	Trace elements

Ghadames	Upper Creta.			20	15	8	8	4	15
	Lower Creta.			20	15	7	7	4	10
	Paleozoic			10	10	5	5	4	10
Eastern part of NWSAS	Quatern.			50	30	15	10	-	
	Upper Creta.			50	30	20	15	-	15
	Lower Creta.			50	30	20	15	2	20
Jeffara plain	Quatern.			50	10	6	6	4	20
	Miocene			50	15	7	7	5	20
	Triassic			30	15	7	7	5	15
Jabel Nafusa	Upper Creta.			20	15	10	12	4	10
	Lower Creta.			30	20	15	15	5	15
Total				380	205	120	107	37	150

3.3 TUNISIA'S NATIONAL PROJECT COMPONENT

Review of the main of objectives of the project:

The major objectives of the national component of the project in Tunisia are the followings:

- Better Characterize the recharge zone area and mechanisms and evaluate the infiltration rate particularly in the Saharian Atlas, Djeffara Plain, Dahar Mountains and Djerid region.
- Provide isotopic characterization of different aquifers layers: Continental Intercalaire (Sidi Aich, Boudinar, Keber El Hadj…), Complexe Terminal (Miocene Sandstone, Eocene and Senonian Limestone), Djeffara (Gabes, Medenine and Tataouine) and Turonian.
- Better define the areas where connections exist between the different aquifers systems (Hamma threshold, ridge of Tozeur, relationship between Dahar and Djeffara) and characterize leakage between different aquifers (relationship CI-CT, relation CT-Turonian, relationship of Chotts salty aquifers with CT).
- Better define the mode of recharge of Djeffara Plain from different hydrogeological relay (Hamma fault, Dahar Area, Mednine fault…).
- Better characterize the recharge of the shallow aquifers (Kebili, Gabes, Tataouine and Medenine) and their relationship with the deep aquifers (CI, CT and Djeffara).
- Impact of the hydraulic infrastructure on the groundwater recharge in the Chott Gharsa and the Atlas areas.

Activities carried out

The major part of the sampling activities planned within the framework of the project, has been implemented. The sampling program covered the aquifer systems in many regions of south Tunisia including The General Direction of Water resources of Tunisia (DGRE) and the commissions for Agricultural Development (CRDA) for Gabes, Medenine, Tataouine, Kebili and Tozeur and the team of the Radio-analysis and Environment Laboratory of ENIS in Sfax.

A total of around 450 water samples have been collected from boreholes, dug wells springs and dams and analysed for their chemical and isotope compositions:

- Chemical analysis : 450
- Stable isotopes : 365
- Tritium : 92
- Carbon 13 and carbon 14 : 170

The pH, conductivity, temperature, static level, and the geographical coordinates have been determined in the field. The Laboratory LRAE of ENIS, (Sfax, Tunisia) carried out all the chemical analyses and Carbon-14 measurements, while stable isotopes (O-18, H-2 and C-13) and tritium were done at the IAEA Isotope hydrology Laboratory.

Remaining work for 2006 and later

The essential of the next field work will interest the :

- ❖ triple point of Borj Khadra-Dabdab-Ghadames (5 sampling points) : In this area we try to look for the comprehensive of hydrodynamic functioning of system in this intersection region relating to the future increasing exploitation.
- ❖ To complete the sampling along the boundary between Tunisia and Algeria, from Matrouha to Borj Khadra (20 sampling points).
- ❖ To complete the collected sampling concerning the Turonian aquifer (10 sampling points).
- ❖ To complete the collected sampling concerning the Shallow aquifers: (aroud of Chott area in Kebili, coastal aquifers and Menzel Habib, Oasis aquifers of Kebili and Rejim Maatoug regions (60 sampling points).
- ❖ Further sampling to survey the piezometric evolution (Hydraulic gradient) and the water quality of the CT and CI aquifers related to a continuous over exploitation of these aquifers.

TECHNICAL REPORT

Major findings and preliminary conclusions:

Modern and Paleorecharge

This study has allowed to :

- confirm that the paleorecharge is effective on the central discharge areas of the Tunisian basin (Nefzaoua,Djerid ,Extreme South and Djeffara).

- Detect a recent recharge near the outcrops limiting the basins and in the free part of aquifers (Draa Djerid,Dahar).

-To show for the first time a recharge from the Saharan Atlas of different aquifer layers and the impact of the hydraulic infrastructure on the recharge aquifer in Tamerza and Chott El Gharsa.

-Confirm the important contribution of the Matmatas and Dahar mountains in the recharge of the Djeffera plain mainly in Mednine region where the presumed effect of a potential recharge from the CI aquifer becomes reduced.

Distinct patterns of chemical and isotope compositions are found in unconfined and deep confined ground waters of the investigated regions. In particular isotope data indicate that significant recharge occurs in the Saharan Atlas, the Dahar and the ridge of Tozeur areas. There are also indications of mixing between old and more recent waters in the recharge area. This phenomenon is characterized by a decreasing gradient from the recharge area towards the confined part of the aquifer. The results obtained so far will be used to refine the recharge input in the flow model and are of paramount importance on the management of the water resources in southern Tunisia and the preservation of their natural water quality.

Objective 2:

The isotopic characterization has been established for the following different aquifer formations:

Continental Intercalaire aquifer system

- Sidi Yaich and Boudinar formations (Djerid area),
- Ain El Guettar and Purbeko-Wealdien (Extreme South region)
- Upper Sandstone, Sandstone “à bois”, Chotts Sandstone and Keber el Hadj Sandstone (Kebili and Hamma regions)

Turonian aquifer system (Djerid, Kebili and Extreme South)

Complexe Terminal aquifer system

- Miocene sandstones (Chot Gharsa and Djerid)
- Senonian limestone (Extreme South and Kebili area)

Djeffara aquifer system

- Miocene sandstones and Upper Senonian limestone (Gabes region)
- Lower Senonian limestone (Gabes South region)
- Trias Sandstone (Medenine and Tataouine regions)
- Jurassic limestone (Gabes- Medenine regions)
- Quaternary formations (Jerba-Zarzis regions)

This will enable the development of an improved conceptual groundwater flow model of the aquifer systems.

Objective 3:

Investigations carried out within this study have allowed the identification of the main zones of hydrogeological relay in the south of Tunisia, especially in the ridge of Tozeur, the threshold of El Hamma and Medenine faults. The isotope results confirm the upward leakage from the CI aquifers to the Djeffara system in El Hamma region. This contribution is very important in El Hamma and decreases toward the coast and Medenine area. This result is very important for the quantification of aquifer budget.

Activities to be carried out in 2005-2006:

For the determination of the recharge rate and the definition of replenishment and mixing zones, more sampling and analysis will be carried out as follows:

- Djeffara Plain (Dahar Area, Mednine fault area concerning the Triassic, Jurassic and Miocene aquifers: 30 sampling points).
- Shallow aquifers: (Kebili, Gabes, Tataouine and Medenine: 60 water points)
  -Underflows: Hamma, Mednine, Tatatouine and Matmata mountains
  -Alluvium aquifers: coastal aquifers and Menzel Habib
  -Oasis aquifers: Kebili and Rejim Maatoug regions
- Djeffara of Tataouine and Medenine
- Medenine coastal plain.
- Djeffara between Tunisia and Libya
- Region along the Algerian-Tunisian borders

Requested input from IAEA:

Training (2005 -2006):
- Regional workshop: oriented to technical staff to master the sampling techniques: 3 technicians from each country
- Training: 4 to 6 Months will be needed for the team working in the project

Scientific Visits:
Four scientific visits (2 months) will be requested for senior scientists and managers

Equipments:
Various laboratory equipments
Whole Tritium enrichment assembly

Expert's mission:
Two missions of experts will be requested for the progress of the project

4. COOPERATION BETWEEN IAEA AND OSS

The Sahara and Sahel Observatory (OSS) was established in 1992 as an intergovernmental organisation with the mandate of promoting regional cooperation in the areas of environmental monitoring and conservation of natural resources. The OSS activities cover the sub-regions of the Maghreb, Sahel and the IGAD countries and are concentrated on: (i) combating desertification; (ii) management of shared water resources in major aquifer systems; and (iii) environmental monitoring.

As part of its efforts to help countries in the different sub-regions to acquire new methodologies and tools to study and monitor natural resources and to assess the impact of human activities on the environment, the OSS has focused its interest on two main objectives:

- The setting up at different scales (local, regional and international) of environmental monitoring networks mainly directed towards combating desertification, characterization of drought and the definition of indicators specific to natural resources,
- The evaluation of water resources and the development of concerted mechanisms for rational management of aquifer systems shared by two or several countries.

Within a regional perspective, the OSS has mainly directed its focus on: (i) the evaluation of exploitable resources and their utilization in the countries concerned with special emphasis on resources of major trans-boundary basins, and (ii) the development of mechanisms for sustainable water resources management.

The OSS is the Executing Agency of the IFAD-funded project on the North Western Sahara Aquifer System (NWSAS) that is under implementation for the period 1999-2005. Through its programmes and networks, the OSS has cumulated in the three countries sharing the aquifer (Algeria, Tunisia and Libya), a significant amount of valuable information which is highly relevant to the objectives and scope of the IAEA supported activities under regional technical cooperation project RAF/8/035. Furthermore, the OSS provides an appropriate regional framework to promote the end-use of the results obtained through IAEA supported activities. The programme carried out by OSS in the countries concerned has led to the following:

- Reassessment of the shared water resources of the Sahara basin on the basis of the new available data (exploration drillings, hydrogeological monitoring) through the utilization of new and performing technologies (databases, GIS and models) with the objective of quantifying the exploitable resources and to better guiding the planning of their exploitation towards an optimal management minimizing the risks of quality deterioration

- Establishing a mechanism of concerted management shared among the countries of the basin and based on legislative and institutional aspects.

The OSS NWSAS project has enabled the countries sharing the basin to acquire new management tools: (i) a digitalized map at the scale of the basin permitting the geo-referencing of the information available on these water resources, (ii) a database regrouping all synthesized and validated information with respect to geology, climatology and hydrogeology, which served as a basis for the development of a performing GIS system, and (iii) a hydrogeological computer model which helps in the simulation of the hydrodynamic behaviour of the aquifer system and in making forecasts for the evolution of these resources during the next 50 years.

The information system developed by the project (database, GIS and digital map) constitutes a valuable tool to better synthesise and interpret the geochemical and isotopic information obtained through IAEA supported project RAF/8/035. In this regard, the availability of a geo-referenced cartographic background like the one produced by OSS is essential for the synthesis of the information at the scale of the Saharan basin. The database developed by OSS is also highly useful for a better interpretation of the results obtained through RAF/8/035.

A related activity relevant to the NWSAS is the study of the aquifer system of the Libyan-Tunisian Djeffara plain. The OSS has carried out during the second phase of the NWSAS

programme (2004-2005) the study of the aquifer system of the Djeffara plain by using tools similar to those of the NWSAS, with similar outputs (database, GIS and computerised topographical and geological background). The region of Djefarra constitutes within the framework of RAF/8/035 a zone well covered by sampling for chemical and isotopic analysis. The tools produced by OSS are very useful for the interpretation of the isotopic data of RAF/8/035 and their synthesis. Furthermore, the collaboration between IAEA and OSS will enable Libya and Tunisia to:

- Refine the determination of the hydrodynamic exchanges of the different aquifer levels within the Saharan system,
- Evaluate with better precision the recharge of the system in the replenishment zones as well as the characteristics of the chemical classes of water according to their different origins,
- Evaluate the scope of the seawater intrusion in the aquifer and its temporal progression.

The meeting participants have made the following recommendations with respect to the IAEA-OSS in relation to the NWSAS:

- Organisation of three regional seminars for interpretation of data (Djeffara plain: Libya-Tunisia, Ghadames basin: Algeria-Libya-Tunisia, Chotts region: Algeria-Tunisia). The countries have to decide of the locations and time of these regional scientific meetings.
- Use the mapping system produced by the OSS team to represent the geochemical data information collected in the framework of RAF/8/035.
- Integrate in the SASS consultation mechanism (monitoring of the SASS aquifers) the use of isotope techniques.
- Direct cooperation efforts of the three countries towards the following: Ghadames basin (Algeria-Libya-Tunisia), Djeffara plain (Libya-Tunisia) and Chotts region (Algeria-Tunisia).

5. OVERALL PROJECT WORKPLAN

A programme of work focusing on trans-boundary aspects of the NWSAS and aimed at filling the gaps has been developed and agreed for the remaining of 2004 and 2005-2006.
It was agreed that each country has the responsibility to ensure that all planned field activities consisting of sampling and pre-treatment of samples are being carried out. Similarly, each country is responsible for carrying out the chemical analyses of their water samples including major and minor ions and selected trace elements.
Support by the Agency for isotope analyses will be provided within available resources to each country according to the specific needs and status of functioning of existing analytical facilities.

On this basis the representatives of the countries developed the national work plans included below.

Work plan for Algeria

	Action by	2004		2005				2006			
		3	4	1	2	3	4	1	2	3	4
Implementation phase											
Individual national activities											
Data review -compilation **Field investigation** **Water level monitoring** **Water sampling** **Analysis** **Data interpretation**	CRNA-ANRH	**** **** 	 **** **** **** 	**** **** **** **** 	**** **** **** **** **** 	 **** **** ****	**** **** **** ****	 **** ****	 **** 	 ****	
Individual manpower training	IAEA-Adminstr										
Expert services	IAEA		****								
Equipment	IAEA	**********									
Sub-contract for analysis	IAEA			****		*****		****			
Group activities	IAEA				***						
Assessment meeting **Field demonstration/work shop** ***Project course work** ***Sampling/analyses** ***Interpretation** ***Presentation of problems by each participant** ***Presentation of individual work programme** **Information dissemination to water managers**	IAEA										
Publication of results **Technical document** **Brochure**	IAEA										

Work plan for Libya

	Action by	2004				2005				2006			
		1	2	3	4	1	2	3	4	1	2	3	4
Implementation phase													
Individual national activities													
Data review -compilation	G.W.A			****	***								
Field investigation				***	***	***	***	***	***				
Water level monitoring				****	***	***	***	***	***				
Water sampling				****	****	****	****	***	***	***			
Analysis					****	****	****	****	***	***	***		
Data interpretation							****	****	****	****	****	****	
Individual manpower training	IAEAr	3-6 months training for 3 persons.											
Expert services	IAEA							****				****	
Equipment	IAEA	**********											
Sub-contract for analysis	IAEA	**********											
Group activities													
Assessment meeting	IAEA						****					****	
Field demonstration/work shop													
***Project course work**													
***Sampling/analyses**													
***Interpretation**													

***Presentation of problems by each participant** ***Presentation of individual work programme** **Information dissemination to water managers**								****	****	****	****	****	
Publication of results **Technical document** **Brochure**	IAEA												

Work plan for Tunisia

	Action by	2004				2005				2006			
		1	2	3	4	1	2	3	4	1	2	3	4
Implementation phase													
Individual national activities													
Data review compilation	DGRE-ENIS			****	****	****	****						
Field investigation				****	****	****	****			****			
Water level monitoring				****	****	****	****	****	****	****		****	
Water sampling				****	****	****	****	****	****	****			
Analysis				****	****	****	****	****	****	****			
Data interpretation						****	****	****	****	****	****	****	
Individual manpower training	IAEA-Adminstr												
Expert services	IAEA							****				****	
Equipment	IAEA	**********											
Sub-contract for analysis	IAEA	**********											
Group activities													
Assessment meeting	IAEA			****			****				****		****
Field demonstration/work shop							****						
***Project course work**													
***Sampling/analyses**													
***Interpretation**													
***Presentation of problems by each participant**													
***Presentation of individual work programme**													
Information dissemination to water managers													

												****	
Publication of results **Technical document** **Brochure**	IAEA	******** **** ****											

ANNEXES

LIST OF PARTICIPANTS

RAF/8/035 – *Evaluation Water Resources of the North-western Sahara Aquifer System*

Second Coordination Meeting
Sousse, Tunisia
5 – 9 July 2004

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Project RAF/8/035– The Use of Environmental Isotopes for Evaluation of Water Resources in the North-Western Sahara Aquifer System

Project Second Coordination Meeting and Technical Workshop

Sousse, Tunisia 5 - 9 July 2004

AGENDA

Monday, 5 July 2004

09.30 – 10.00 **WELCOME AND OPENING CEREMONY**

- Introduction of Participants
- Opening Remarks
- Background and Objectives of the Meeting:
- Adoption of Agenda
- Appointment of Chairpersons and Rapporteurs

10.00 – 10.30 Overview of implementation of Agency's support

10.30 – 11.00 *Coffee Break*

11.00 – 12.00 Country presentation – **Algeria**
12.00 – 13.00 Country presentation – **Libya**
13.00 – 15.00 Lunch
15.00 – 16.00 Country presentation – **Tunisia**
16.00 – 16.30 Coffee Break
16.30 – 17.30 Discussion of presentations and summary of achievements

End of day

Tuesday, 6 July

09.00 – 10.30 Evaluation of the isotope results in terms of how they can help refine the existing groundwater flow model of the NWSAS
10.30 – 11.00 Coffee Break
11.00 – 12.30 Evaluation of the isotope results in terms of how they can help refine the existing groundwater flow model of the NWSAS (cont)
12.30 – 14.30 Lunch
14.30 – 16.00 Working groups to design specific country work plans
16.00 – 16.30 Coffee Break
16.30 – 17.30 Working groups to design specific country work plans

Wednesday, 7 July

09.00 – 10.30 Preparation of project overall programme of work
10.30-11.00 Coffee Break
11.00-12.30 Project work programme (cont)
12.30 – 14.30 Lunch
14.30 – 16.00 Project work programme (cont)
16.00-16.30 Coffee Break

16.30 – 17.30	Project work programme (cont)

Thursday, 8 July

09.00 – 10.30	Finalization of work programme
10.30-11.00	Coffee Break
11.00-12.30	Finalization of work programme
12.30 – 14.30	Lunch
14.30 – 16.00	Preparation of meeting report
16.00-16.30	Coffee Break
16.30 – 17.30	Preparation of meeting report

Friday, 9 July

09.00 – 10.30	Review of the meeting report
10.30-11.00	Coffee Break
11.00-12.30	Review of the meeting report
12.30 – 14.30	Lunch
14.30 – 15.30	Wrap up discussion, conclusions and recommendations
15.30 –16.00	Closing of meeting