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Digital Models: Assessment and Management Tools for Assistance in Decision-Making Coastal Dune Tablecloth Algeria

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Abstract: The free water table of the solid dune mass of "Bouteldja" belongs to the "Mafragh" hydro system. Its mode of layer and its boundary conditions hinders the management of this tablecloth particularly in period of dryness. Numerical modeling using the software MODFLOW-Waterloo-Canada allowed to establish the hydrous assessments of 21, 16 and 8 Hm^3, after the simulation of the scenario of natural refill of the tablecloth average and the cyclic dryness 5, 10 and 20 years. These evaluations indicate the tablecloth levels of exploitation, which must imperatively be respected to maintain the hydrodynamic balance and the eco-systems Eastern "Numidie" wetlands associated with this tablecloth.

Key words: Water table, management, period of dryness, numerical modeling

INTRODUCTION

In this study, are studied the problems of evaluation and management of subsoil water resources of the water table of the solid mass dunaire of Bouteldja. This tank has a complexity from its mode of layer in sandy formations bordered at north by the Mediterranean and the south by the system fluvio-paludous of the Wadi Kébir Is, this situation confers to him hydrodynamic limits with potential imposed on North and in the South East (Dérichlet) in North East it is a limit with flow (Neumann). This hydro system constitutes specificity to belong to the field of the wetlands of Numidie Eastern by (Samraoui and Deblair[1] and Nafaa,[2]).

For a better knowledge, particularly in an acute cycle of dryness, potentialities of this underground water tank and the planning of its estimated management, our contribution is the implementation of an application of the software Visual Modflow v.2.11 (developed and developed by Waterloo hydrogeologic[3]) conceived like Outil of simulation of scenario-after construction and chock of the digital model in permanent and transitory mode of the aquiferous system of the natural refill of the tablecloth due to the infiltration of the effective rains in period of dryness.

MONOGRAPHIC SYNTHESIS

Geographical framework Cf fig N°1: The surface of study is located at the extreme North East of Algeria, covers a surface of 150km^2 and extends on the unit from the formations dunaires from Bouteldja. It is limited:1-To North by the Mediterranean sea, 2-With the South-western-south by the fluvio unit-paludous of the alluvial plain of Mafragh and the marshes of marshes of Bini Urgines.3-A Is by the sandy formations argilo djebels karoussaa and limiting El kourssi Ces defines the hydrodynamic borders of the water table.

The hydrographic network of this zone belongs to the hydro system of Mafragh to which is attached the Kébir Wadi Is of which affluents of its right bank the such Wadi, Bourdime and El Bahim, occur indeed in the solid mass dunaire that they then drain in high waters to maintain the zone discharge system the lake and paludous surface formed of garaat and marsh extending from Righia to the black lake: true complex of the ecosystem of this part of the wetlands of Numidie Eastern to operation quasi depend on the hydro system alluvio -dunaire of Boutedja by (Gaud,[4]; Kherici,[5] and Drici,[6]).

The zone of study is characterized by a climate of the Mediterranean type the annual averages of precipitations, temperatures and relative humidity of the air is, respectively 691.68 mm, 17.5.°C and 70% L' real

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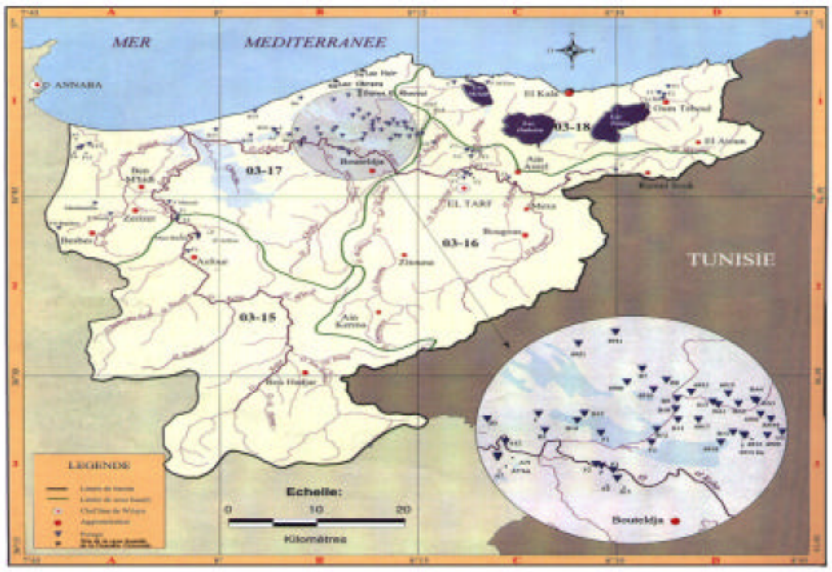

Fig. 1: Chart of the hydro system of mafragh and localization of the tablecloth of the solid mass of bouteldja

Table 1: Values of the effective infiltrations relating to the years dry

Period of return (years dry)	Corresponding years	Effective infiltration (mm)
5	69-79-80-87-89-2002	140.
10	1968	106.5
20	1996	59.4

evapotranspiration are estimated at 430 mm, the clear infiltration would lie between 15 to 25% (Nafaa,[2]; Matmati,[7]) of the water blade of the fallen rains.

Frequential study of the hydrous assessments and estimate of the reserve régularisable in period of dryness: Pursuant to the model of Thorantwait by (Matmati,[7]) to the data relating to the station of Bouteldja. The results of the annual balance sheet reveal a very strong ETP with an average of 872.32 mm and an average ETR of 423.14 mm representing approximately of 63 % of the rains. On average the rough surplus is 255 mm is 37% with a minimum and maximum, respectively of 57 mm (1996) and 640 mm (1990) described by (Nafaa, 2003).

The series of the surpluses annual Nets (deduced streaming) was adjusted with the law Gamma, to consider the rains effective relating to the periods of return of dry years and their corollary the exploitable reserve.

The results of Table 1 show that the refill due to the effective rains is 140, 106.5 and 59.4mm/an respectively for the dry years of recurrence 5, 10 and 20 years; these values are characteristic of the hydrous deficits criticize in particular that of the year 1996. They will be consequently simulated on the mathematical model developed in the continuation of this contribution.

EVALUATION AND EXPLOITABLE STOCK MANAGEMENT

Definition and simulation of scenario on the pessimistic assumption (period of dryness).

Presentation: Taking into account its mode of layer and boundary conditions, the water table remains very vulnerable to the marine and/or brackish water invasion from where risks of degradation, in order to suppress any pollution generated by these phenomena, it thus appeared imperative to analyze in seen to evaluate the exploitable resource in period of secheress and to propose a solution for its management Cette approach is built on the basis of pessimistic scenario of assumption because the vulnerability of this tank presents durable problems of development within the meaning of the paradigm 4th defined by its vectorial components: socio-economic and éco technical and to study by the multicriterion analysis of the risk, for the decision-making in the strategy of hydrous stock management Bagnoulis,[8].

Cette reference suggests for the joint use of subsoil waters and surface (Sahuquillo,[9])-practised in the area of the study-maintaining balance hydrodynamic of the tablecloth in period of risk and its corollaries: the quality of water and the harmonious development of the wetlands

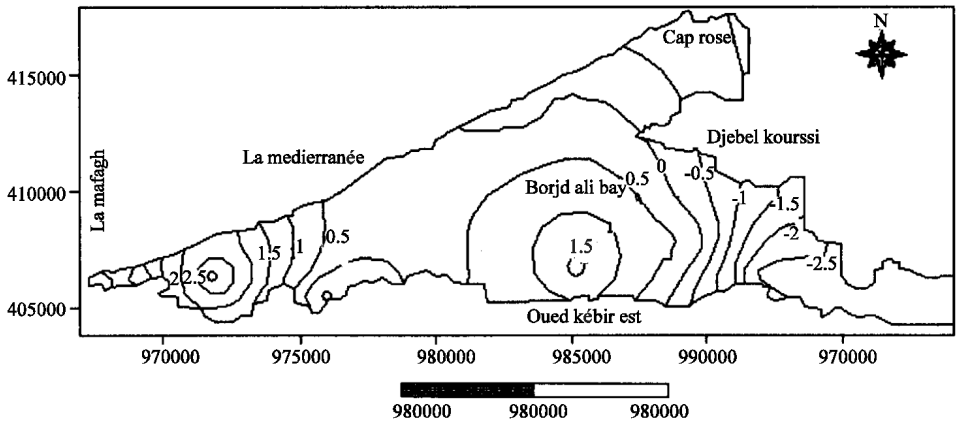

Fig. 2: Chart of the beats piezometric: high and low waters of the tablecloth dunaire of Bouteldja 1982

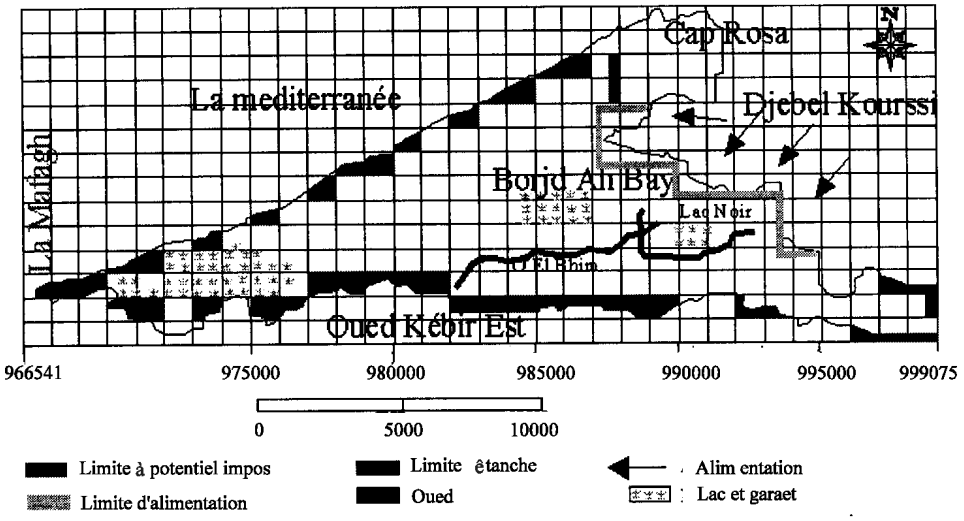

Fig. 3: Chart of the boundary conditions and descritesation of the field of the tablecloth

Ces forced are then conditioned by the rigorous respect of the optimal piezometric coasts:objet of the continuation of this contribution. After characterization and chock of the mathematical model in permanent and transitory mode of the tablecloth dunaire, one will procèdera with the estimate by the digital simulation, of the exploitable resource for the period of dryness of reference.

Recalls of the characteristics of the tablecloth of the solid mass dunaire: The various studies carried out in the area showed: Has the existence of a significant tablecloth made up in the blow sands resting on the one hand on the substratum numidien in North East of Bouglès and on the other hand on the filling Mio-Pliocène of the pit of Ben Me Hidi in the West;

B That waterlogged sands pass laterally to the gravels of the deep tablecloth of the gravels to the south. The thickness of this water table varies between 40 and 140 m (Keherici,[5]; Nafaa [2] and Matmati,[7]). The boundary conditions (Fig. 2) of the free tablecloth of the solid mass dunaire of Bouteldja, were defined by (Gaud,[3]; Zaalani,[6] and Matmati,[7]). They are identified and defined as follows: 1-Le long of the littoral, the Mediterranean drains the northern part of subsoil waters;2-A is the solid mass dunaire receives surface waters of the solid masses numidiens; 3-With the south the tablecloth dunaire feeds the tablecloth of the gravels;3-Of the outcrops of tablecloth in the form of marshes exists in various points of the solid mass dunaire (Fig. 2). The hydrodynamic characteristics the such transmissivity (or permeability)

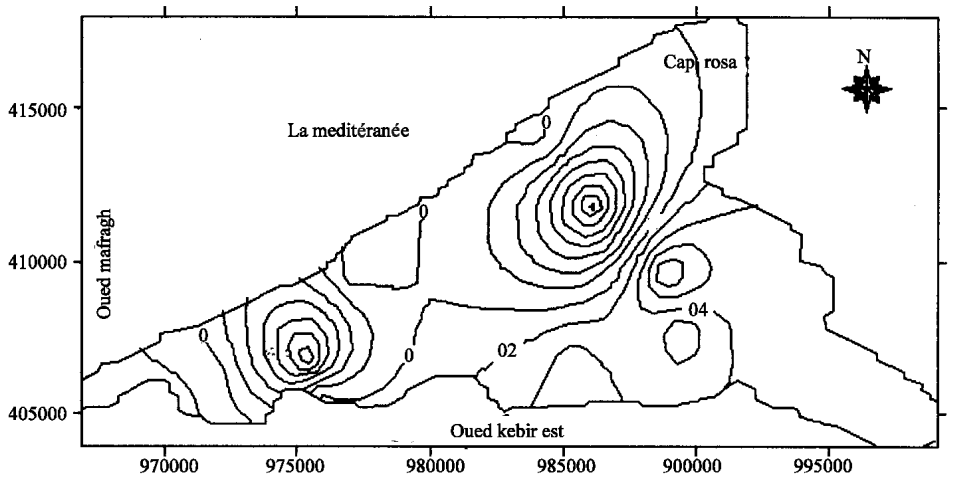

Fig. 4: Chart of the differences between the pièzomètrie simulated and observed in transitory mode

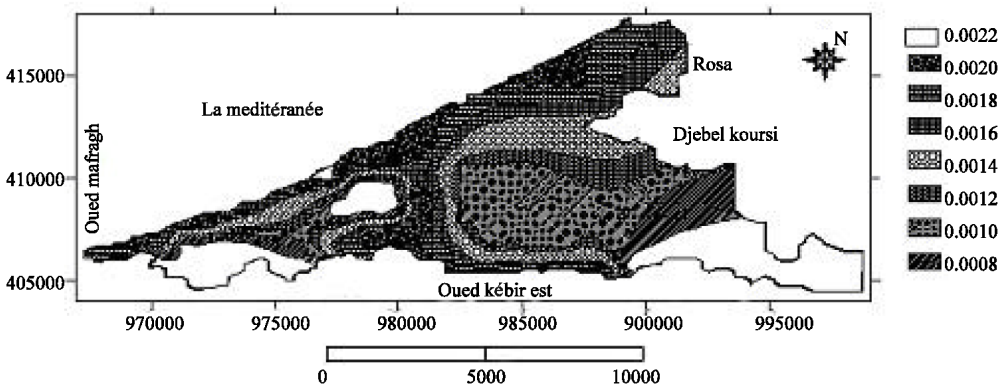

Fig. N°5: Space distribution card of the permeabilities (m/s) after chock in transitory mode

and effective porosity are draw from the former studies (Gaug,[3]; Kherici,[5]).Les values of the transmissivities are included/understood entre 10^{-4} and 1.3 10^{-2} m^2/S and of coefficients of storage are on average 4-5 %; it characterizes a free tablecloth. Period of measurements, one noted a volume of the exits estimated at 25 hm^3 representative 30% of the annual rains of the water resource year 1982.

CONSTRUCTION AND DEVELOPMENT OF THE DIGITAL MODEL OF THE TABLECLOTH

Application of the software Visual Modflow: The geometry of the aquifer and the data available made it possible to exploit the simulation program Visual Modflow v 2.11.

Discretization of aquiferous space: The limits of the aquifer were described to define the conditions of the model for this purpose, the edges of the aquifer are: Limits with side flow no one; limits with imposed side flow; limits with constant hydraulic potential (Fig. 3)

Principle of the chock: During phases of chock two objectives are required:-La reproduction of a stable state of the pièzomètrie in permanent and transitory mode. The prime objective corresponds to the chock of the model in permanent mode for the local values of permeability of the aquiferous formations and the vertical permeabilities of immediate strata. During the chock in transitory mode, the reproduction of the piezoelectric fluctuation makes it possible to adjust effective porosity.

Chock of the model: With end to be able to assess the quality of the chock one carried out the construction of the charts of the differences between piezometry measured (1982) and calculated by the model.

Simulation in permanent mode: The difference between the actual values and calculated pièzomètrie is large with

Table 2: Simulated assessments of the dry years and average (Nafaa Matmati,[2])

	Entrees hm³				Exits hm³			
Years dry	Bilan hm³	Potential Imposed hm³	Reload by the effective Rain hm³	Imposed flow hm³	Bilan hm³	Potential Imposed hm³	Pumping hm³	Difference /entrees exits hm³
1996:T=20ans	8.91	0	7.21	1.70	24.35	5.62	18.73	-17.14
	100%	0	72%	28%	100%	23%	77%	237.7%
1968:T=10 ans	16.6	0	15.2	1.	16.6	2.60	18.73	-4.3
	100%	0	91.5%	6.5%	100%	15.78%	112.8%	28.5%
2002:T=5 ans	21.1	0	19.37	1.73	21.1	2.37	18.73	-1.73
	100%	0	91%	9%	100%	11%	89%	8.9%
Average year	34.46	0	32.74	1.62	34.46	15.73	18.73	0.0
	100%	0	93.5%	6.5%	100	45.64	54.36	0.0

an average error of the order de7.44 m. En modifying the zonal values of the permeabilities after several essais/erreurs, this variation was minimized to reach a relative probability of the spatial distribution of the Horizontal Permeability (MH). These variations remain higher than 3 m.(valeurs absolute) in certain meshs located in the zones North Is, in addition the variations lie between 0.5 and 2 m elsewhere. Consequently the chock is considered passably acceptable, it will thus be improved in the stage of the transitory mode.

Simulation in transitory mode: In transitory mode the coefficient of storage estimated at 4.5% by (Nouacer,[10] Drissi,). The chock was carried out on the basis of monthly pièzomètrie of the year 1982-1983 and the average refill y related. The boundary conditions are those definite higher. The results of the chock are illustrated by the Fig. (Fig. 4). At the final stage of the chock, differences between calculated and measured pièzomètrie: Piezometry 1982; (Kherici,[5]) are deferred on Fig. 4, the latter reveal a sufficient chock of the model

The distribution of the permeabilities resulting from the final chock in transitory mode can then be regarded as representative of the water table. The Fig. 4 shows the space distribution card of the permeabilities.

With this stage one considers that the digital model of the tablecloth of Bouteldja is sufficiently representative of the aquiferous systèe; it can thus make it possible to make simulations of the refill by the effective rains of the years of dryness and to thus establish the hydrous assessments of the inputs/outputs.

SIMULATION AND ANALYZES SIMULATED ASSESSMENTS OF THE YEARS 1996, 2000 AND 2002

Presentation of the results of simulation

Analyze assessments: According to Table 2, the exploitable reserves in the tablecloth dunaire are variable from one year to another; the year 1996 remains drier and would correspond to a recurrence of decennial secheress Bi. The deficit is very significant; it reaches for the extreme year of dryness the 238% of the reserve régularisable Pour the average year and under the current conditions of operating of the tablecloth, the assessment is relatively balanced, on the other hand it is appreciably negative for the other dry recurrences Ces results are to be considered in the policy of the maintenance of the hydrodynamic balance of the tablecloth whose operation depends completely on the ecosystem of the biodiversities of these wetlands. The durable development in such complexity of a related medium, requires actions of planning of the installation as of the these water resources having to take account of the various constraints related as well to the hydro system as with the ecosystem which are completely associated for him. In conclusion, it is strongly recommended to exploit only only water due to the natural refill; the recourse to alternation[10].

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