Vulnerability to pollution of Mitidja plain alluvial aquifer (Algiers-Algeria)

O. Mimouni[1], G. Cheikh Lounis[2], S. Kabouche[3], H. Menceur[4]

FSTGAT / USTHB, Algiers-Algeria

Abstract: Hydrochemical analysis of Mitidja plain alluvial water, upon several years, were made and visualized by maps. An relatively important evolution of chemical elements concentration in time and space was noticed. Considering this increasing risk, vulnerability maps were drawn for a better management of water quality.

Keywords: alluvial aquifer, Mitidja, pollution, vulnerability, hydrochemical maps.

1. INTRODUCTION

Mitidja plain is spread along a WSW-ENE direction on about 80km length and 10 to 20km width. Its total area is around 1300 km2. It is separated from the sea by the Sahel of 280m height, and thus on a 70km distance. To the East, in Réghaïa region, it is directly in contact with the sea. On the whole surface, it is crossed by different wads flowing from south to north starting at Blida mountain. From East to West, these wads are: Réghaïa, Hamiz, Djemaa, El Harrach, Chiffa, Bouroumi and Djer. These wads drain all kind of materials while crossing urban and agricultural zones, where wastes are thrown without treatment. The plain is vulnerable and mostly in some spots where the alluvial aquifer is in contact with the Astian aquifer.
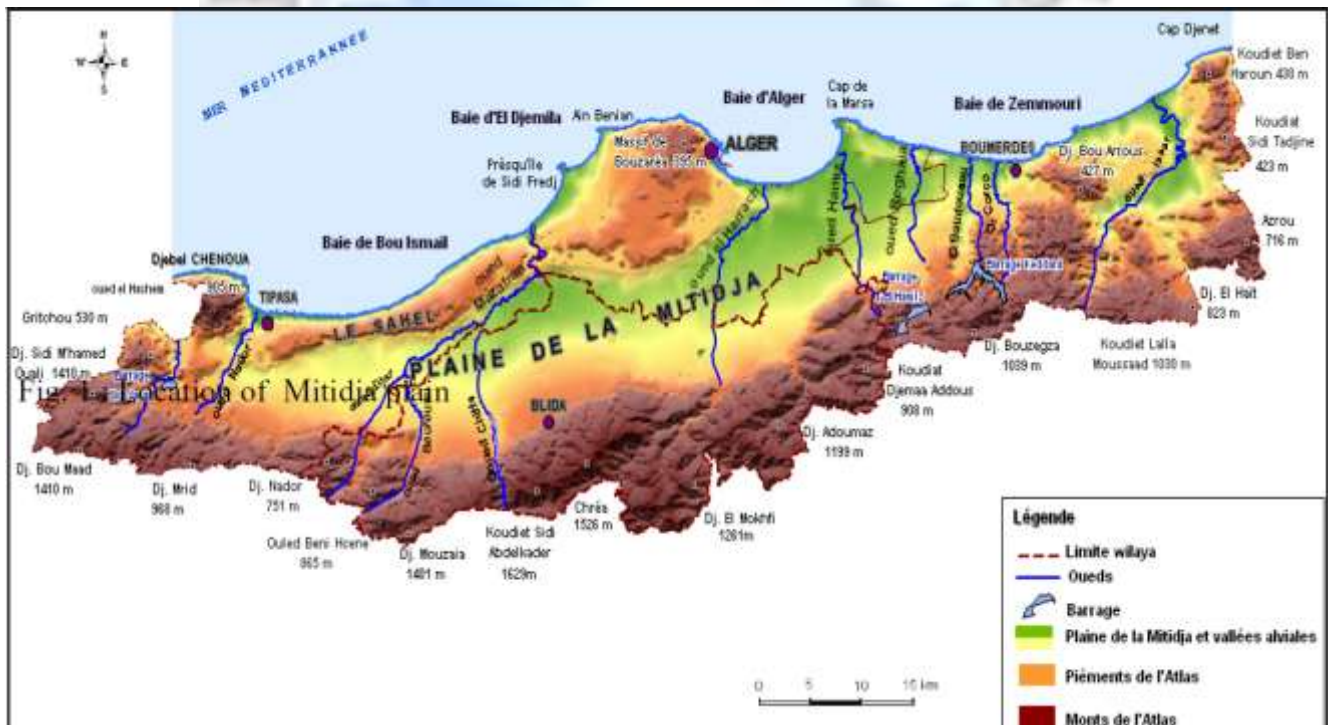

Fig. 1 : Location of Mitidja plain

2.   Vulnerability to pollution of Mitidja plain

To study the vulnerability of the Mitidja plain, a modified DRASTIC method   called DRIST was selected among different methods. Only five parameters are used for transmitting pollution from the soil surface to the aquifer. The parameters are resumed in table 1 :

Table 1 : DRIST Parameters

Parameters	Description	
D	Depth	profondeur de la nappe
R	Recharge	recharge naturelle
I	Impact	impact de la zone vadose
S	Soil	nature du sol
T	Topography	topographie

D : parameter determined from maps and piezometric measures. It is important in the transfer control and pollutant attenuation in the unsaturated zone. This parameter hard to estimate, often requires field measurements.

R : A tough parameter to evaluate. It depends on several factors ; geological, geomorphologic, pedologic and et climatic. Therefore it is an important factor influencing infiltration and recharge in the aquifer on one hand, and pollutant transfer on the other hand.

I : parameter expressing impact of vadose zone, ie physical and chemical effects that may occur during water flow to saturated zone . It depends on lithologic nature of media where phenomenon of self-purification may occur.

S : important parameter since it is the filter for groundwater It is obtained by pedologic maps and profiles.

T : topographic parameter showing soil relief. Il is therefore directly related to infiltration, which influences pollution propagation toward groundwater. For each parameter, we drew a vulnerability index map using tables giving the listing and weight of each annex parameter.

To calculate vulnerability index $\mathbf{I_V}$ by modified DRASTIC method (DRIST) :

$$\mathbf{I_V} = (\mathbf{Dr \ x \ Dw}) + (\mathbf{Rr \ x \ Rw}) + (\mathbf{Ir \ x \ Iw}) + (\mathbf{Sr \ x \ Sw}) + (\mathbf{Tr \ x \ Tw}) = \ \mathbf{ND + NR + NI + NS + NT}$$

With :   **D,R,I,S,** and **T** : parameters defined earlier :

 r et **w**   represent respectively   weight and listing attributed to   each   considered   parameter. Piezometric measures are important for realizing the vulnerability map. We used the 2008 piezometric data.

Depth index map N_D :

To realize this first depths map (D) we used ANRH piezometric maps of 2007 and 2008. For that we used values of static level Ns and took all Z-NS points which allowed us, using Surfer, to draw this map. The procedure will be carried in several steps and the first will begin by the selection of the parameters. The others will all have their own particularity :

Table: 2 Table of parameters and their sources.

Parameters	Information Sources
D – Water depth	Recent piezométric Maps 2007/2008) ANRH-DRC Soumaa.
R – Annual Recharge	Hydrogéological Studies : - Mathématical Modèle of Mitidja plain. Binnie & Partners, 1983. - Study of Hydro-agricultural plain of Mitidja, AGROCOMPLET-ENERGOPROCT.1978. General pattern of water development of Mitidja plain -vol.IV. Geological and hydrogeological study -.ANRH. Alger. -Sir M.Mc Donnalds & partners ltd, WS Atkins & BNEDER, Algerie 1992.
I Impact of the vadose zone	Geological maps Geophysical Studies (CGG, ALGEO) Boring Logs (>180)
T – Topography	Topographic Maps (INCT)
S - Soil Types	Pedological Studies- documents ANRH. Profiles and Pedological Study of Hydro-agricultural planning of Mitidja plain

To determine the first index N_D, we need to consider the listing after considering its weight, where N_D = weight x listing and this on each mesh. These values are given in the two tables below. (3&4)

Table 3 : Parameters and their weight..

DRASTIC Parameters	General Weight
D – Water depth	5
R – Annual Recharge	4
I - Impact of vadose zone	5
T – Topography	1
S - Type of soil	2

Table 4: Depth Intervals

Intervals (m)	Aquifer depth (Côte)
0 – 1.5	10
1.5 – 4.5	9
4.5 – 9	7
9 – 15	5
15 – 22	3
22.5 – 30	2
> 30	1

By superposition of the grid, which is the mesh of the Mitidja plain, we obtain values of depth index and from there the depth indexes map N_D (fig2)
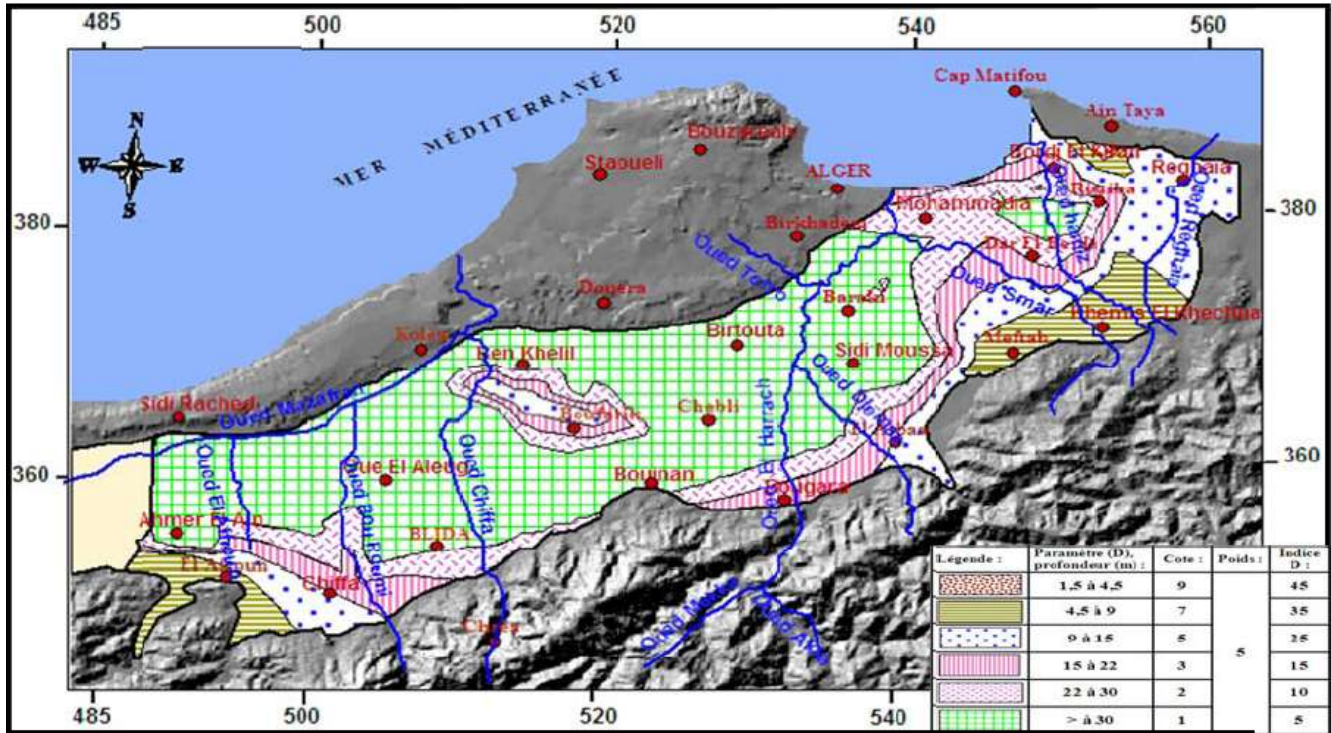
Fig 2: Depth index map.

We have six different depth of the alluvial aquifer as shown in the above legend : The first class of depth between 1.5 et 4.5 meters The second class of water depth level is in between 4.5 et 9 meters, is somehow more important. The third depth class is between 9 et 15 meters, contains three geographical zones located in the Mitidja plain. The fourth depth class between 15 et 22 meters, and the fifth with depth 22 to 30 meters, are twa practically parallel bands.The sixth class, the most preponderant, of depth varying from 22 et 30 meters represent a large part of the plain from the west to the center. We proceeded in the same way for the other parameters to obtain maps of the different indexes N_I, N_S et NT and thus considering weight and list parameters shown in tables for each index. We finally were able to draw the maps of the different vulnerability indexes:

3. Recharge index map N_R

We were unable to access data base of other parameters (R, I, S and T), and considering that they have a low probability to vary with time, we calculated these values by digitalization of vulnerability index maps drawn previously. We have here three classes with indexes from 24 to 36, and the first one have a recharge between 10 à 18 cm/year The second one have a recharge from 18 to 25 cm/year is located in three regions Baraki, Rouiba and Reghaia. The third class with a recharge over 25 cm/year occupies the rest of the plain in a large area

4. Impact of vadose zone index map (N_I)

This map is very important. In fact it is a key parameter which represent the characteristics of the transition zone of the polluting agent to the aquifer. Its width and nature are essential characteristics. The realization of this map is based on a study of several borings (180). We obtained five classes of different lithology with indexes values from 15 à 40.

class 1, with a clayey , silty and marly texture. This fine texture correspond to a weak vulnerability to pollution.

class 2 is composed of sand and clay

class 3, composed with coarser elements like gravels and pebbles with clay is also spread all over the plain.

class 4 is identical to the precedent but with more coarse and fine sand and thus is more permeable and therefore more

vulnerable to pollution.

class 5 contains coarse elements and some clays and have the highest vulnerability index .

5. Soil map index (N_S)

We defined here 4 categories of soil with a low spread index values since I_S varies between 2 and 12. These different natures of soil are a mix between clayey soils and silt and sandy soils. In the first category we have clayey soils where in the second we have silty clay soils with very high clay percentage. In the third category the difference with the first one is the clay percentage. The fourth category is a sandy loam soil with highest vulnerability index is found in the major part of the plain.

6. Parameter map (T), topography of Mitidja alluvial aquifer

Since topography is relatively flat in the plain, we have three classes for this index:

Class 1, with very low slope , 0 to 2% representing the e la majority of the plain from east to west.

Class 2, with a slope of 2 to 5%,   occupying a band along the Blida massif Larbaa. flank from Chiffa to

Classe 3, representing a relatively high slope, and located in two points : one in the Birtouta zone and the other in Khemis El Khechna.

7. Vulnérability map of Mitidja plain: I_V index

The superposition of these different indexes maps allowed us to realize the vulnerability to pollution map of the Mitidja alluvial plain aquifer(Fig3). The map was established using I_V indexes obtained with three classes of vulnerability, high, medium and low. The determination of hydrogeological units was done according to Aller and Al by superposition of five thematic maps and use of borings datas, that gave the described units 2A, 2B et 2C.
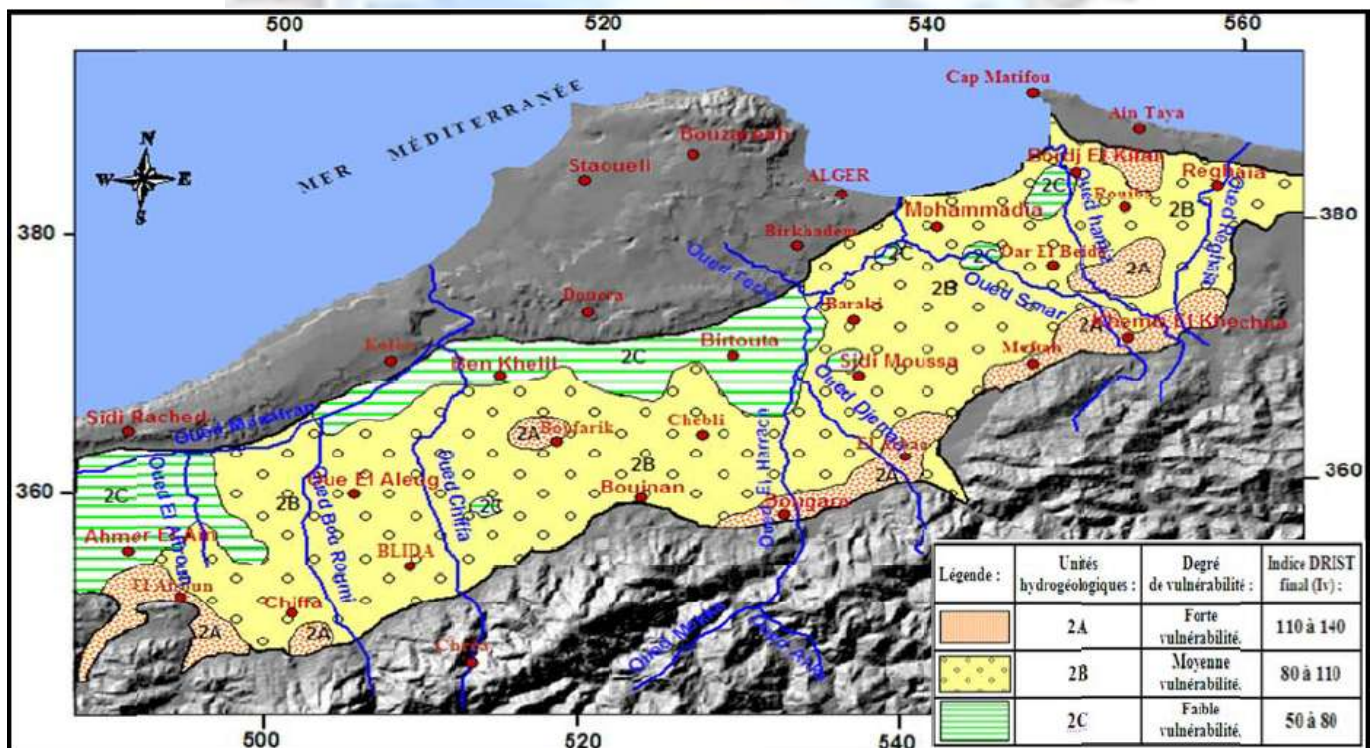

Fig. 3 : Vulnerability to pollution of Mitidja alluvial aquifer map. O. Mimouni.2008. (Application of DRIST method).

From the map an unequal distribution of vulnerability zones is noticed. The predominant and most represented area is of average vulnerability. It practically covers the whole Mitidja area. Some disparate areas are those of high level vulnerability and might be of serious danger. In the aim of enhancing potential sources of pollution in the Mitidja plain in general and the El Harrach wad in particular, we proposed a superposition of the vulnerability map, the industries and the discharges location maps. (fig. 4)
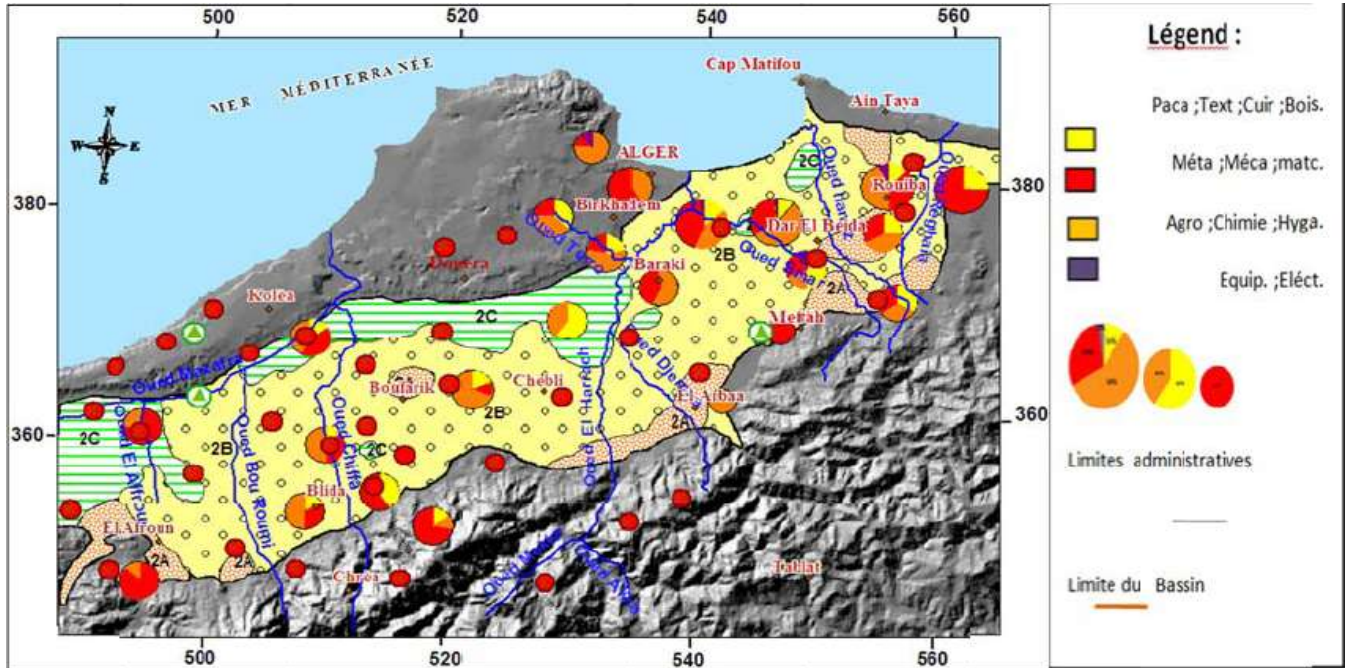

Fig. 4: Industries and discharges location map.

For the whole plain, most of the discharges is located in the center of the plain of essentially Mitidja alluvial formations. We know that most industries discharge their wastewater without treatment which increase the contamination in the most vulnerable zones. For the El Harrach watershed a discharge is located nearby which might increase pollution.

Conclusion

The modified DRASTIC method applied in our case for Mitidja alluvial plain vulnerability to pollution is an improved method based on depth, recharge, nature and topography of soil, and vadose zone. . The result, a vulnerability map superposed to industries and discharges location maps is a good tool for engineers and managers concerned by a clean future that will help them to make the right decision. Using this tool we can anticipate on the pollution risk in the most threatened zones.

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