Mapping the index of the quality of groundwater (GWQI): Khemis Miliana Alluvial Plain, Algeria

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Abstract

Groundwater is the most important natural resource used for consumption by many people around the world, particularly in rural areas. In Algeria, since the quantity and quality of water available for different uses varies from one place to another, the quality of groundwater in the alluvial plain of Khemis Miliana will be evaluated for its ability to purposes consumption. To this end, an attempt will be dedicated mapping in this study to determine the spatial distribution of the parameters of groundwater quality and to identify better locations for drinking water supply in the study are. The methodology will be structured on the basis of: an integrated analysis of physical-chemical parameters, using known geographic information system (GIS), and calculates the Quality Index (GWQI). The physico-chemical results will be compared with the Algerians in 2011 for drinking water standards.

Keywords: Groundwater, Quality of water, GIS, khemis Miliana plain.

General Introduction

Groundwater is an important source of drinking water for many people around the world, particularly in rural areas. Groundwater can be contaminated from natural sources or many types of human activity. The residential, municipal, commercial, industrial and agricultural can also affect groundwater quality. Contamination of groundwater can lead to poor quality drinking water, loss of water supply, expensive remediation costs, as well as potential health problems, such contamination of groundwater resources present a risk to the user of local resources and the natural environment (Fatta et al 1999).

Natural resources and environmental concerns, including groundwater, have benefited greatly from the use of GIS. Typical examples of applications of GIS in the groundwater quality studies are numerous: analyzes the relevance of the sites, qualitative management of aquifers, evaluation of groundwater vulnerability to potential pollution, quality assessment groundwater spatial models for decision support to management. Hudak (1999, 2000, 2001) and (Hudak and Sanmanee 2003). In addition, the quality of groundwater, mainly governed by the extent and composition of dissolved solids, is of great importance in determining its suitability for drinking water supply. (Jasmin et al 2014)

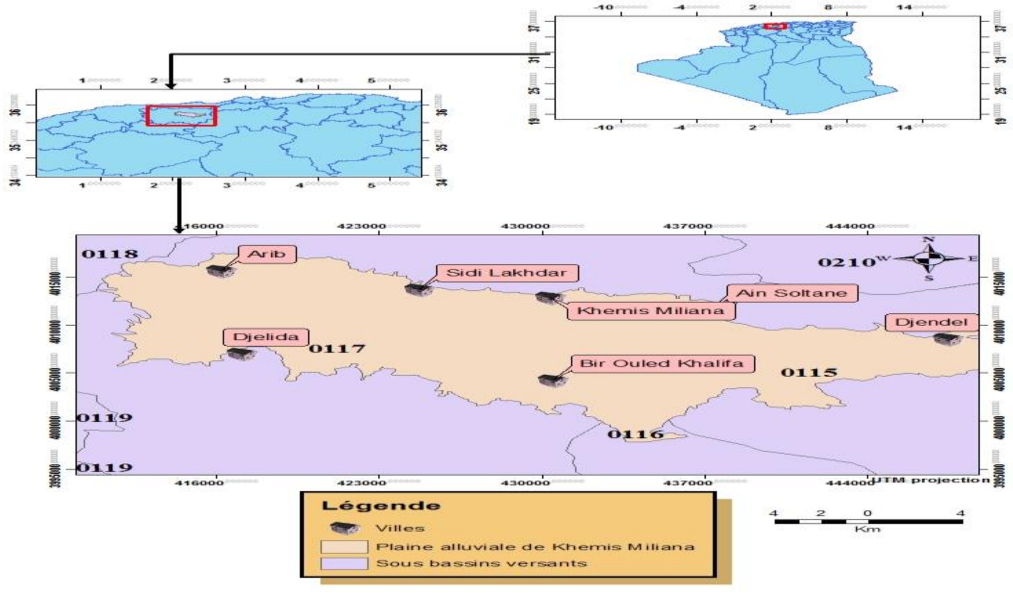
Groundwater is the most important natural resource used for consumption by many people in Algeria, especially in rural areas which is part our study area called alluvial plain of Khemis Miliana. Sveral hydrogeological studies in the area have shown that groundwater in the plain showed signs of contamination in a wide range of measurement point. The quality of groundwater in the alluvial plain of Khemis Miliana will be evaluated for its suitability for consumption. To this end, a mapping attempt will be dedicated in this study to determine the spatial distribution of groundwater quality parameters and identify better locations for drinking water supply in the study area.

In this research, a simple attempt to formulate water quality indices and maps, using Algerian standards of drinking water was conducted in the plain. The fundamental objective of the current research is to develop an index of the quality of groundwater (GWQI) as a tool for monitoring the quality of groundwater. The GWQIs developed aim to quickly distinguish the location of more water and less suitable for potable water consumption. By mapping this index in GIS platforms, areas of groundwater discretized in quality can be easily distinguished by scientists and policy makers and the general public of the region.

Materials and methods:

Study area:

The study area is the upper valley of Cheliff, alluvial plain of Khemis Miliana, it is located 120 km south-west of Algeria, it belongs to the sub watershed high Cheliff, in the northern part of the Algeria. Its area is 359.5 sq km and its perimeter reaches 159 km, It is ranked among the largest groundwater reserves in the area. It is considered an area whose main activity is primarily agricultural.



Pict 01: The location and delimitation of the Study Area.

The alluvial plain of Khemis Miliana-part sub basins Cheliff N°: 01-15, 16 and 17. The area of this plain is 359.5 sq km and its perimeter that reaches 159 km, it is characterized by an elevation average of 270 m. It is ranked among the largest groundwater reserves in the area. Spatially, it is between the latitudes the northern borders of the alluvial plain of Khemis Miliana are surrounded by the massive Zaccar (1576 m), and the South by the first reliefs of Ouarsenis, one enters Eastern by Djendel threshold, and West exits through Doui threshold.

Methodological approaches

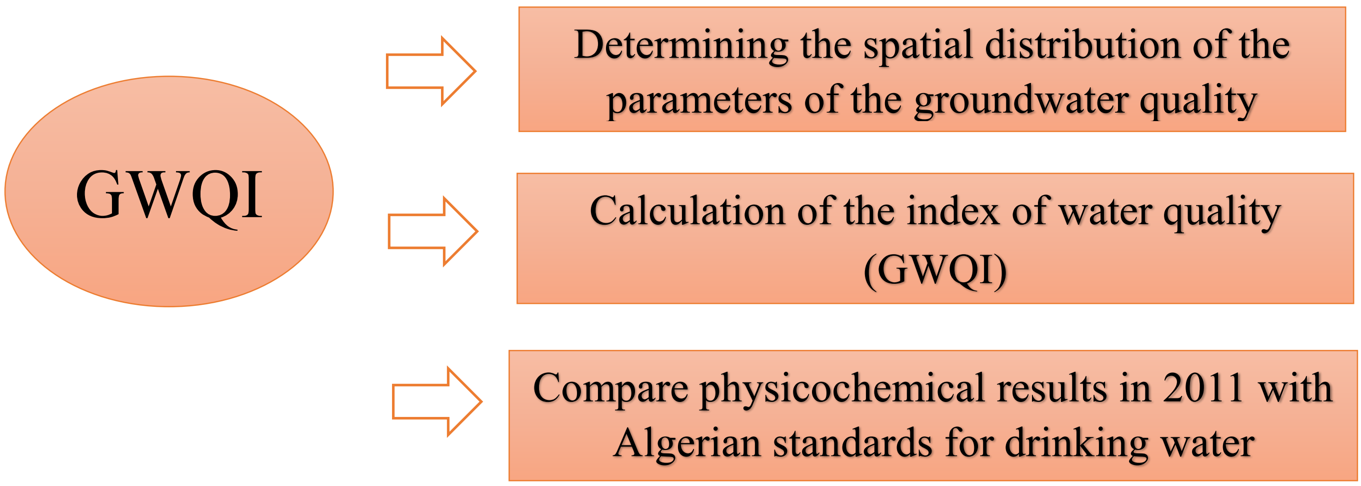
Data collection

Twenty sampling points (boreholes, wells and piezometers) were selected in the study area, respecting a certain homogeneous geographic distribution. Water depths are between 5 and 50 m, touts the samples reside in the same context hydrogeological (coarse silt). The sampling was done over the years 2010 to 2014 for the month of May (low water period) assisted the team ANRH Khemis Miliana. Water samples were collected in bottles and polythene were analyzed in the laboratory of Blida ANRH for 11 parameters, ie., temperature, pH, electrical conductivity (EC), (TDS), dissolved oxygen (OD) Total alkalinity (TA), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), nitrate (NO_3^{-}) Sulfates (SO_4^{-}). The physicochemical analysis was performed by conventional methods. TDS is calculated indirectly EC EC 0.64 × (S / cm) (Raghunath, 2003). Bicarbonates more were calculated from the alkalinity 1.31 × alkalinity (Hem JD, 1985).

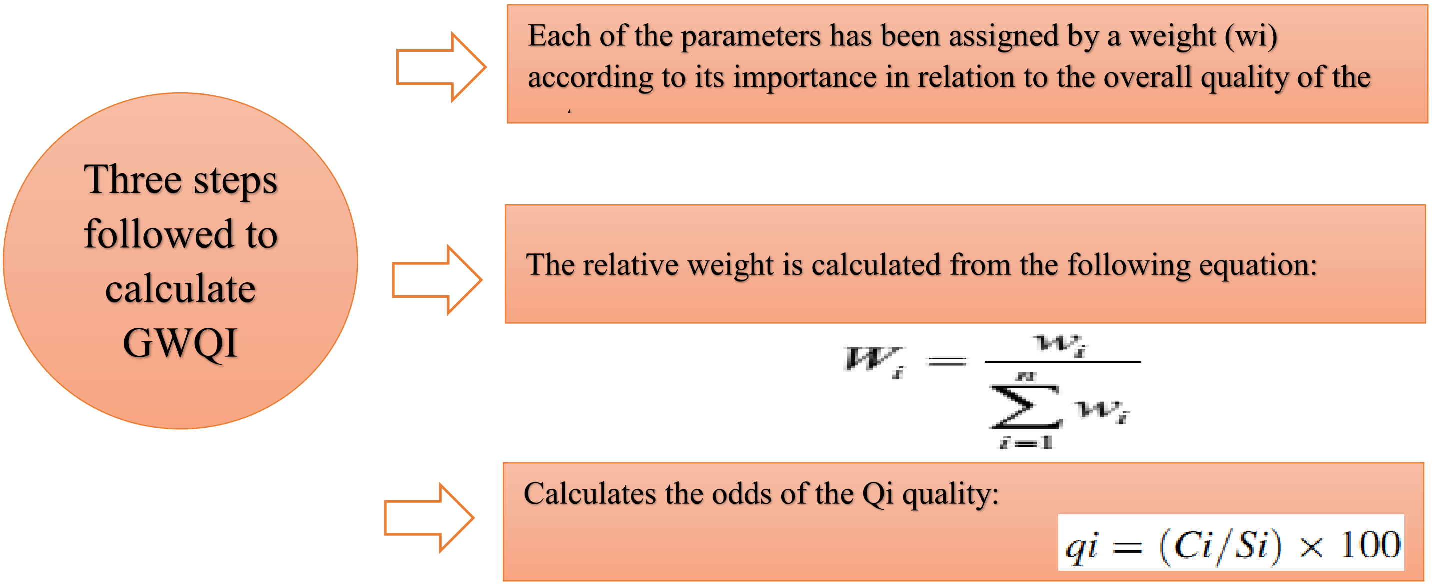
The accuracy and reproducibility of analytical measurement and ion balance the studied ions were ± 5%. The background maps of the study area was prepared using a Landsat satellite image using the Arc GIS® 10.2 software. The UTM projection system was used to locate the position of each sample point and the coordinates were imported to the GIS platform for the preparation of the base map. Geochemical results are shown on the diagram piper Trilinear and celuide Scoeller-Berkalov's using Diagramme^{R}, and to evaluate the mechanisms of dominance hydrogeochemical facies of the study area.

Method

Mapping groundwater quality by index approach



Index of groundwater quality (GWQI)



Three steps are followed to calculate the GWQI. In the first step each parameter was assigned a weight (wi) in terms of its importance in relation to the overall quality of water intended for AEP. A maximum weight of 5 was assigned to the parameter nitrate due to its importance in the assessment of water quality. In the second step, the relative weight is calculated from the following equation:

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i}$$

Wi is the relative weight **wi** is the weight of each parameter and **n** is the number of parameters. The calculated values of **Wi** are given in the **table01**.

In the third stage, a rating scale (score) the quality **(qi)** for each parameter is assigned by dividing his concentration with the standard concentration respectife fixed according to the guidelines set out in the Algerian Executive Decree No. 11-125 of the standard 17 Rabie Ethani 1432 corresponding to March 22, 2011 relating to the quality of water for human consumption. And the result is multiplied by 100.

$$qi = (Ci/Si) \times 100$$

Ci is the concentration of each chemical parameter in the water sample in **mg / L**, and ***Si*** is the standard of the Algerian drinking water for each chemical parameter in **mg / L** according to the guidelines of the Algerian standard set in Decree.

To calculate the GWQI the ***SIi*** is first determined for each parameter. The sum of ***SIi*** values gives the index of water quality for each sample.

$$SIi = Wi \times qi$$

$$WQI = \sum SIi$$

SIi is the sub-index of the nth parameter

qi is the rating based on the concentration of the nth parameter

n the number of parameters.

Results and Discussion

Table01: the relative weights of physicochemical parameters

parameter	Algerian standard	weight (wi)	relative weight (Wi)
pH	9	4	0.11428571
TDS	1500	5	0.14285714
Ca	200	2	0.05714286
Mg	50	1	0.02857143
Na	200	2	0.05714286
Cl	500	3	0.08571429
SO4	400	4	0.11428571
NO3	50	5	0.14285714
K	12	2	0.05714286
CE	2800	4	0.11428571
HCO3	200	3	0.08571429
		$\sum = 35$	

Table02: Classification of groundwater quality according GWQI

Class	class index	Type of water
	<50	Excellent water
	50 - 65	Good water level 1
	65 - 85	Good water level 2
	85 - 100	Good water level 3
	100 - 125	Poor water level 1
	125 - 135	Poor water level 2
	135 - 150	Poor water level 3
	150 – 165	Very poor water level 1
	165 - 185	Very poor water level 2
	185 - 200	Very poor water level 3

The distribution of the index of Growndwater quality (GWQI)

The cards Growndwater quality Index (GWQI) in the alluvial plain of Khemis Miliana was realized based on the mapping of each parameter individually, we will outline the final results of the index.

According to the interpretation of index cards obtained during the low water period for the years (2010-2014), we conclude that the waters of poor and medium quality characterize the majority of the study area, the distribution of the index is characterized by good quality downstream of the plain the main factor may be due to the dilution of components to the flow direction and the central part unscrewed into two; poor quality for the North and very poor quality for the South is the factor of the increase due to salt-bearing outcrops Théniet El Had through Oued Massine, and poor quality upstream of the plain.

Conclusion:

Groundwater is inherently susceptible to contamination caused by human activities and natural, treatment becomes very expensive in recent years. Prevention against contamination of groundwater is essential for effective and sustainable management. In Algeria the rehabilitation of groundwater quality is poor almost impossible. In this memory, an attempt was made to assess the quality of groundwater in the alluvial aquifer of the plain of Khemis Miliana, Algeria.

The hydrogeochemical point of view, the chemistry of groundwater revealed that groundwater in the plain of Upper Chéliff have essentially a calcium chloride-facies concentrations of chlorides and sulfates are widespread, especially in the southern part where we see signs of contamination.

The index of the quality of groundwater (GWQI) has been formulated from a formula based on 8 cationic and anionic chemical elements, as well as pH, EC and dry residue. The established mapping represents the spatial distribution of GWQI. A spatial distribution of the chemical elements of groundwater and their spatiotemporal evolution were mapped. The analysis maps showed that the waters of poor and medium quality characterized the majority of the study area, the water quality is significantly down due to the gradual evolution of chlorides, nitrates, sulfates and dry residue.

The groundwater quality decreases from North to South of the plain, the western part of the area is characterized by good quality, the main factor may be due to the dilution of the elements in the direction of groundwater flow. In 2014, analysis of the map of the spatial distribution of GWQI showed that the downstream part of the study area is affected by good quality which has 16% of the total surface of the plain, 73%, 11% of the total area has a quality 'Poor water quality level 1, good water level 3. The study of the spatial and internal evolution temporally showed that the years 2010 and 2012 are the most affected in terms of contamination as the years 2011, 2013 and 2014.

recommendation:

• Periodic monitoring of water quality

• National use optimal and reasonable quantities of fertilizers and plant protection products to avoid the risk of nitrate leaching.

• The development of water resources and the economic and social development can't be considered separately. This is one of the indispensable elements for a development plan is realistic and can be applied. It is also necessary to meet a goal of sustainable development so the development of water resources.

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