Study of groundwater pollution of irrigated Ain Zohra commune (North-eastern Morocco) by nitrates using GIS. Understanding the Climate–Water–Energy–Food Nexus and the Transition Towards a Circular Economy: The Case of Morocco

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Abstract. The contamination of Morocco's water resources comes from three sources as like agriculture, industry, and urbanization. Within this project's scope, we investigated groundwater contamination in the suburban community of Ain Zohra (located in the Mediterranean zone, Driouch province, eastern part of Morocco). The Zohra area is limited in east part by the rural municipality of Ain Zohra, in the north part by Driouch city and in the southern and western parts is bounded by the Boubker rural municipality. In July 2021, 21 samples were taken from the field (20 wells and 1 spring). In general, the results of this study showed that some water wells are highly mineralized as the conductivity is far above the drinking water standard. Every well's pH is basic. Nitrate contamination in two places shows that the permeability of city soil affects the groundwater. The nitrate content might be higher than groundwater, which has 200 mg/l. In certain wells, groundwater contamination has raised organic matter levels above drinking water regulations. The water quality maps of some parameters were obtained based on application of Geographic Information System (GIS) for the study area. ***Keywords***: pH, Nitrate, Conductivity, Ain Zohra, Groundwater,GIS.

1 Introduction

Use Water is one of the essential natural resources for living things. This resource is finds in several phases in the hydrologic cycle, the water cycle comprises water in the atmosphere, the oceans, the landscape and the subsurface [1] and can be affect by many contamination due to the various human activities including industrialization and agricultural practices [2]. However, it may also be a source of illness since it is a transporter of potentially hazardous substances [3–5], such as pathogenic microorganisms and chemical compounds. It can make it a possible vector for disease transmission [4–6].

The use of significant amounts of nitrates [7–9], which may be found in drinking water, has been linked to adverse effects on public health, including the development of some malignancies and infantile methemoglobinemia [10–12].

In Morocco, the prevalence of infectious illnesses like hepatitis and typhoid is exacerbated by the use of groundwater drawn from public or private wells that do not have enough protection against contamination, as well as by a lack of knowledge on proper hygiene practices [13–16].

In Ain Zohra City, situated in the northeastern part of Morocco, the demands and conventions of intensively irrigated agriculture, in addition to the discharge of wastewater into the groundwater, are having an adverse effect. We provide the present salinity, nitrate, nitrite, and orthophosphate levels found in contaminated groundwater. These substances have a direct connection to the methods used in agricultural production. In

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addition, we evaluate the level of microbiological contamination brought on by septic tanks. The objectives of this study is to mapping and describe the water quality of Ain Zohra groundwater based on the results of many field and laboratory parameters measurement (TDS, CE, Salinity, Nitrate).

Geographic Information Systems (GIS) are practical tools that can make significant contributions to a variety of applications, including the environment, health, land use planning, wise use of natural resources, and disaster prevention [17,18].

The paper is structured in four sections: Section one represents the introduction part, section 2 focused on the of the study area description, the data, and applied the methodology. Section three provide the results and discussion, and section four conclusions are given in the last section.

2 Material and methods

2.1 Description of the research area

Rural commune Ain Zohra is located in Driouch province, and is bordered by the towns of "Driouch" to the north, Ouled Boubker and Saka to the east, Mzguitane to the south, and the city of Tizi Ousli forms its western border (province of Taza). The study area is covering a surface of 252.5 Km^2. The Ain Zohra region is characterised by a semi-arid climate. The annual temperature ranges between 2°C and 38°C with an average of 20°C, the annual rainfall is around about 240.3 mm. A certain number of winds, with an average annual speed of approximately 50 Km/h, pass through the commune.

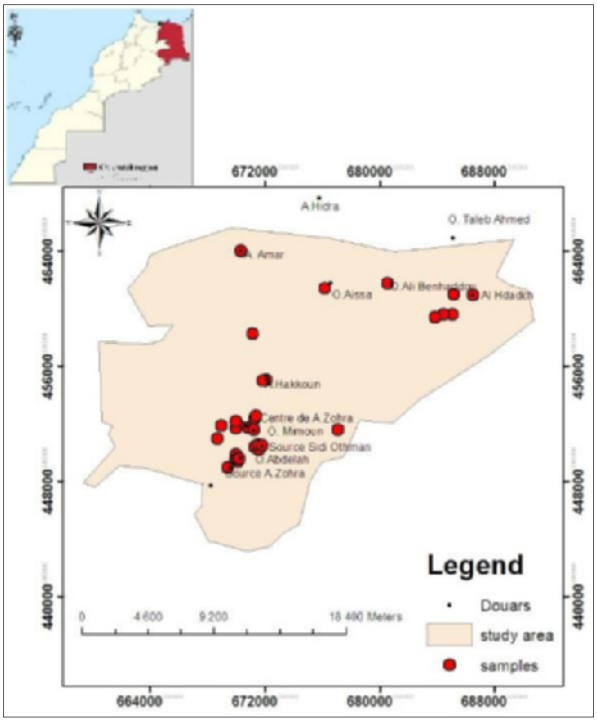

Fig. 1. Map of situation of the municipality of Ain Zohra.

2.2 *Methodology*

A major sampling campaign was conducted to determine the water quality, firstof all, the samples was taken in the wet season of July-August 2021.Some physico-chemical parameters are measured in situ in field such as the temperature and pH were measured using a portable pH meter (VWR), the electrical conductivity (CE) was measured using a portable conduct meter (COND 330i / SET), and the piezometric levels were measured using a piezoelectric sonde. Two samples were transported to the exact location, one for bacterial analysis in sterile glass bottles and the other for chemical analysis in 500 cm3 polyethylene bottles that had been thoroughly washed in the laboratory with distillate water and cleaned several times with distilled water before sampling All water samples were immediately chilled to 4°C in a portable freezer before being transferred to the laboratory. The chemistry analysis for the significant ions was carried out by the protocols outlined below:

- As specified by the international standard ISO 17294-2:2016, nitrate measurement is used to determine the water quality of the sampling water. The analysis of certain chemical parameters as Nitrites, nitrates, phosphates on of the sampled waters were carried out using the spectrophotometer [20–23].

2.3 *Data processing*

In the first step of the process, the data collected during the physicochemical investigation was analyzed using a GIS approach. Second, the hydrochemical process was going on at the same time as the other operations to investigate the functions of water mineralization and water accumulation and discover the factors that contribute to the formation of these water clusters. The model parameters were analyzed concerning the guidelines that the World Health Organization had established for water drinking. Different findings may be produced using a geographical information system and shown on various themed maps (GIS).

3 Results and discussion

An examination of the Ain Zohra aquifer's physical properties was carried out in 2021. They concentrate mainly on the pH and conductivity levels of the water.

Table 1. Physical-chemical element descriptive statistics Variable.

Variable	Mean	Minimum	Maximum	WHO Standard [24]
pH	7.39	7.14	8.14	6.5-8.5
EC	2.96	0.88	12.76	2.50
T°	18	16	20	
Nitrite	0.48	0	1.41	
Nitrate	130	0	260	50

3.1 Hydrogen potential (pH)

The pH may be affected by the place where the water originated and the characteristics of the traversed landscape. It poses a risk to the physicochemical equilibrium of the water and causes alterations in response to the mineral dissolution and precipitation processes [25–27]. The pH values of the wells that were analyzed are within the safe boundaries for use as a source of drinking water. [24], which is between 7.14 and 8.14 (Fig.2).

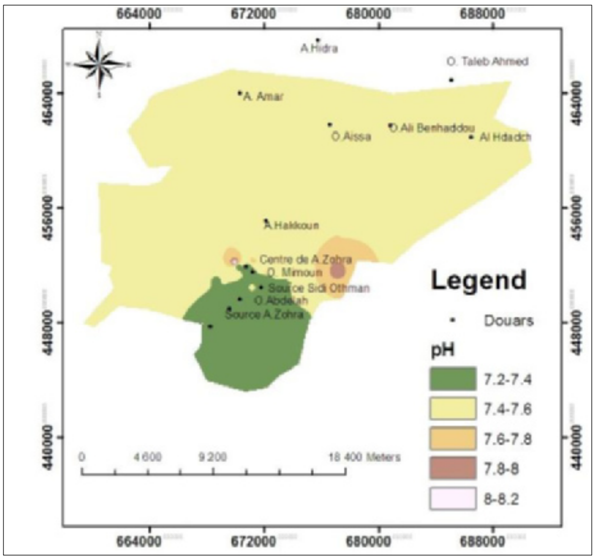

Fig. 2. pH distribution map in Ain Zohra groundwater

3.2 Conductivity

That's the representation of the dissolved load, which gives an information about the degree of water mineralization.

In addition, it is because ions that are free to move about in an electric current are present in the medium. [3,5,6,28]. The readings vary from 880 to 13760 s.cm-2, which is 30 percent higher than the threshold established by the WHO (Fig. 3).

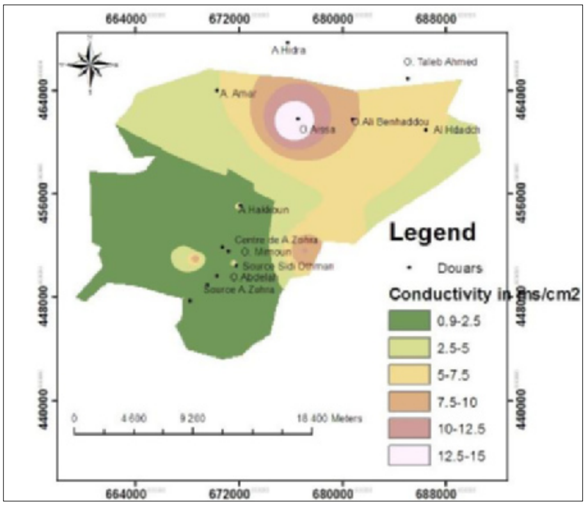

Fig. 3. Conductivity distribution map in Ain Zohra groundwater.

3.3 Nitrate

During the year of 2021 rainy season, levels of nitrate in the unconfined aquifer varied from 0 (well P22) to 250 mg/l (well P21) (Fig. 4).

The readings that were observed for 35% of samples were higher than a basic level of 50 mg/l that has been established by the World Health Organization (WHO) (Edition, 2011) as the limit for drinking water. The most significant levels of nitrate pollution in groundwater were recorded for the study area in the southern section of Ouled Aissa and Ain Amar, as shown by the spatial variation maps of nitrate in groundwater in Ain Zohra (Fig. 4). This was the case for the whole region.

In general, investigations have revealed that nitrates might have originated from a variety of sources, including the following:

Nitrates as a result of agricultural intensification (clearing, removal of pastures), nitrates from people and animal's organic matter, as well as plant natural, make much difference (organic soil improvers), nitrates from artificial fertilizers [29–31].

Nitrates relating to human activities inherent to urbanization, industrialization, and focused livestock farming, individually and collectively contribute linked to human activities inherent to urbanization, automation, and intensive livestock farming [23,32,33].

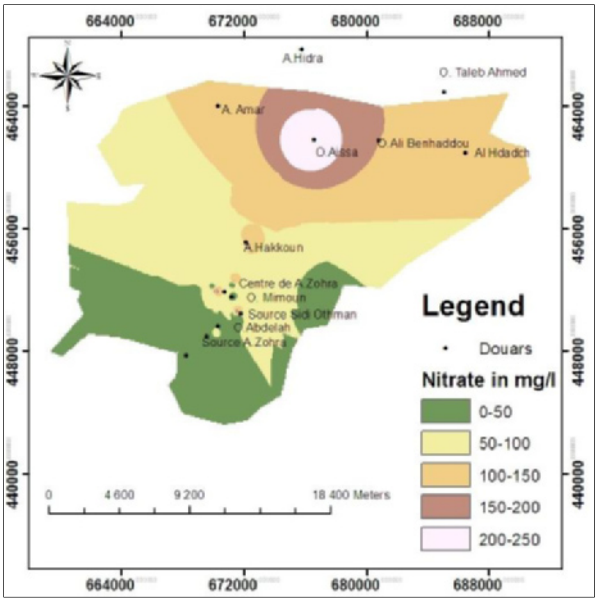

Fig. 4. Nitrate distribution map in Ain Zohra groundwater.

3.4 Nitrite

The results of Nitrite parameter (Figure 5) show that the values range between 0 and 1.2.

The most part of the study area has low values (< 0.6), the relatively high values of the Nitrite (>0.6) are mostly located in the west and in the north parts of the basin.

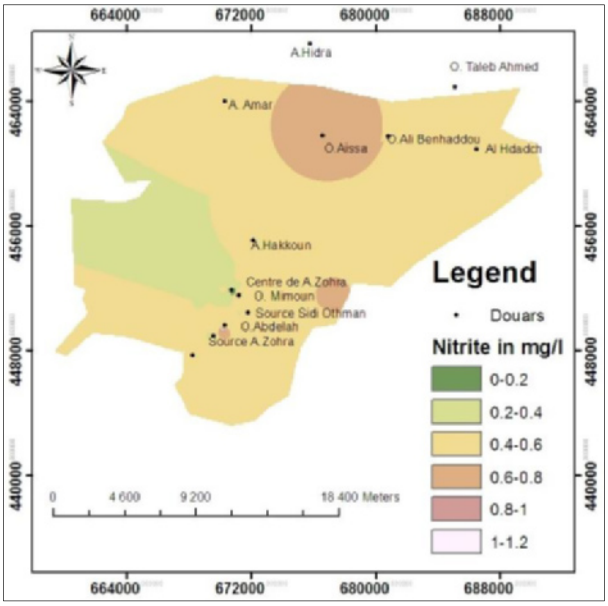

Fig. 5. Nitrite distribution map in Ain Zohra groundwater.

Table 2. Summary of the results analysis

Sample	code	T°C	pH	EC	NO_2^-	NO_3^-
Puit 1	P1 AZ	18	7.21	1.25	0.4	43
Puit 2	P2 AZ	18	7.22	0.94	0.39	10
Puit 3	P3 AZ	18	7.15	1.11	0	104
Puit 4	P4 AZ	18	7.28	0.88	0.34	55
Puit 5	P5 AZ	18	7.32	9.23	0.39	11
Puit 6	P6 AZ	18	7.35	1.7	1.41	107
Puit 7	P7 AZ	18	7.2	1.62	0.49	17
Puit 8	P8 AZ	18	7.4	1.16	0.4	15
Puit 9	P9 AZ	18	7.14	2.33	0.48	232
Puit 10	P10 AZ	18	7.37	1.04	0.36	48
Puit 11	P11 AZ	18	7.53	0.9	0.37	43
Puit 12	P12 AZ	18	8.14	2.51	0.38	15
Puit 13	P13 AZ	18	7.34	1.78	0.72	15
Puit 14	P14 AZ	18	7.45	1.17	0.38	41
Puit 15	P15 AZ	18	7.2	2.22	0.52	5
Puit 16	P16 AZ	18	7.22	4.27	0.49	193
Puit 17	P17 AZ	18	7.68	1.37	0.4	6
Puit 18	P18 AZ	18	7.36	1.84	0.46	165
Puit 19	P19 AZ	18	7.42	3.11	0.4	161
Puit 20	P20 AZ	18	7.42	3.1	0.45	50
Puit 21	P21 AZ	18	7.48	13.76	0.8	260
Puit 22	P22 AZ	18	7.76	9.58	0.67	0
Source ain zohra	SAZ	18	7.33	1.2	0.33	26

4 Conclusion

The management and evaluation of the water quality are done regarding the levels of physicochemical parameters. The collected findings indicated that there had been a decline in the quality of the groundwater found in the Ain Zohra aquifer. Nitrate pollution of wells and spring water during wet and dry times indicated that their levels surpassed the WHO standard limit for drinking water in around 35% of samples. It was the case for both samples collected during wet and dry periods. In addition, nitrate pollution in groundwater rose during the wet season in 73% of the instances. It was caused by leach from rainfall and irrigated during this time of high agricultural activity, which occurred during the wet period. The salinization events in Ain Zohra Town are another indicator of the worsening groundwater quality in this region. The electrical conductivity measurement revealed that the groundwater's mineral content was relatively high.
We had a hunch that focused irrigated agriculture was the primary culprit behind diffuse nitrate pollution due to the excessive and reiterated application of nitrogen-containing chemical fertilizers and manure. On the other hand, we suspected that septic tanks were the cause of groundwater contamination with faces germs.

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