Environmental Systems Research

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Assessment of groundwater quality and health risks in Ketama region (intrarif), Morocco

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Abstract

For many reasons, water from wells and natural springs is still widely used in Morocco. 90 groundwater samples were analyzed to assess the health risks associated with its quality in the Ketama region, including physicochemical analyses such as pH, electrical conductivity, total dissolved solids, bicarbonates, and nitrates using standardized methods, as well as bacteriological analyses covering total coliforms, fecal coliforms, *Escherichia coli* and fecal streptococci utilizing the membrane filtration method. Assessment of groundwater physicochemical quality showed that 13.41% of samples had nitrate concentrations exceeding the maximum value set by the World Health Organization (45 mg/L). In comparison, 12.16% of samples were slightly acidic (pH < 6.5). Bacteriological analyses of the groundwater showed that the water points studied are contaminated with total coliforms, faecal coliforms, *Escherichia coli*, and faecal streptococci at rates of 80%, 50%, 35%, and 36%, respectively. In conclusion, groundwater in the Ketama region presented potential risks for users, particularly regarding waterborne diseases.

Keywords Diarrhoea, *Escherichia coli*, Fecal coliforms, Groundwater, Incidence, Nitrate

Introduction

Water, the essential basis of life, remains a crucial resource for the survival of all beings on earth. However, its availability is decreasing considerably due to climate change and other factors (Rabearisoa et al. 2024). Access to drinking water remains a significant challenge in many developing countries. In 2020, 368 million people used wells and unprotected springs, while 122 million people collected untreated surface water from lakes, ponds, rivers, and streams (Unesco. 2023). The situation in Morocco is particularly worrying, with wide disparities. Indeed, 91.3% of the urban population has access to improved water sources, while only 37.8% of the rural population, representing 73% of the general population, has the same access (Sadeq et al. 2021). This disparity calls for immediate attention and action.

Diseases linked to environmental health kill 12.6 million people every year, including 846000 deaths from diarrhoeal diseases (OMS 2016). According to the World Health Organization (2006), the probability of diarrhoea is 39.1% for African south of the Sahara, compared with 7.2% in developed countries. 1.8 million people, 90% of them children under the age of 5, die every year from

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diarrhoeal diseases (particularly cholera), mainly in developing countries. Infectious diarrhoea is common throughout the world. The most suspected pathogens are rotavirus, *E. coli*, *Shigella*, and *Cryptosporidium*. 88% of diarrhoeal diseases are linked to water pollution, inadequate sanitation, and poor hygiene (OMS 2017). According to the WHO, the number of water and sanitation related deaths in Morocco has been estimated at 1661 in 2019.

Another factor in water quality degradation in arid and semi-arid regions of the world is nitrate (NO_3^-) contamination of groundwater, which has become one of the most alarming problems (Adimalla et al. 2018). Many forms of pollution have been associated with NO_3^- concentrations in water above 3 mg/L, including waste discharges, sanitation, and agricultural activities such as excessive fertilizer use, improper disposal of animal waste, and uncontrolled irrigation (Egbi et al. 2020). High nitrate concentrations are mainly due to these farming practices, which began in the early twentieth century (Ernesto et al. 2014). To assess water quality degradation due to NO_3^- contamination, the WHO sets a maximum permissible value of 45 mg/L (WHO 2017).

However, it is crucial to note that one of Morocco's 2030 targets, set by the Sustainable Development Goals (SDGs), is to "guarantee access to water and sanitation for all and ensure the management of water resources." This urgent issue requires the monitoring of drinking water quality.

The central focus of this study was to thoroughly examine the physico-chemical and bacteriological quality of groundwater in the Ketama region. The study aimed to shed light on the potential health hazards that the population in this area might be exposed to due to using this unsafe water source.

Materials and methods

Study area

The study area lies between 35°0′0″ to 34°40′0″N and 4°20′0″ to 4°50′0″W, covering a total area of 956 km^2. The climate in the Al Hoceima region alternates between dry and wet seasons. The average monthly temperature is between 13 and 24 °C, and the average annual rainfall does not exceed 400 mm (Ghalit et al. 2017).

The study area consists of 9 rural communes, including Taghzout, Bni Bouchibet, Abdelghaya Souahel, Issaguen, Moulay Ahmed Cherif, Tlat Ketama, Tamsaout, Bni Bounsar, and Bni Ahmed Imougzen (Fig. 1). The total population of the study area is 114649 (Haut-Commissariat au Plan du Maroc 2014), a vast population. The population varies from one commune to another, ranging from 8112 inhabitants (Bni Bouchibet commune) to 24013 inhabitants (Abdelghaya Souahal commune).

Condition for protection and exploitation of groundwater

In the study area, all the wells were of traditional realization with a depth between 5 and 30 m. Most (60%) did not have protective equipment (coping, lid, platform). Springs (99%) have no means of protection (Fig. 2). However, the boreholes, a significant source of water, were adequately protected with electric pumps with depths up to 100 m, ensuring the safety of the water supply. After water is removed, the population transports and stores the water in buckets and cans. These waters were used for drinking and various domestic uses.

Chain of disease transmission

The hygienic evacuation of excreta is an integral part of the sanitation of the environment. Inadequate and unsanitary drainage leads to soil contamination and water supplies. It often allows certain fly species to breed, feed, and spread the infection. It attracts pets, rodents, and vermin that disperse feces, creating favorable contamination conditions.

In transmitting these diseases to healthy individuals by patients or carriers of germs, the sequence of events is the same as for many other communicable diseases. The following elements are necessary for this transmission:

- A causal agent;
- A reservoir (or source of infection) of the causative agent;
- A means of transmission between the reservoir and the new host;
- A receptive host.

Transmission patterns are of varying importance. Water and food may be important, but in other cases, flies and other insects or direct contact may be predominant (Fig. 3).

Sampling

In 2021, 90 groundwater samples (48 springs, 20 wells, and 22 boreholes) were collected in the 9 rural communes (Fig. 1).

Groundwater was collected in clean 1.5 L polyethylene bottles, rinsed twice with the water to be collected for physicochemical analyses, and in sterile 500 mL bottles for bacteriological analyses, after pumping for 10 to 15 min (Adimalla and Qian 2021a), for wells equipped with pumps to eliminate stagnant water and obtain representative results. Before each sampling for bacteriological analyses at wells and boreholes with pumps, the valves were sterilized by a gas torch. After sampling, the groundwater samples were identified, stored at 4 °C in insulated boxes with cold refrigerated tanks, and transported to the laboratory for analysis.

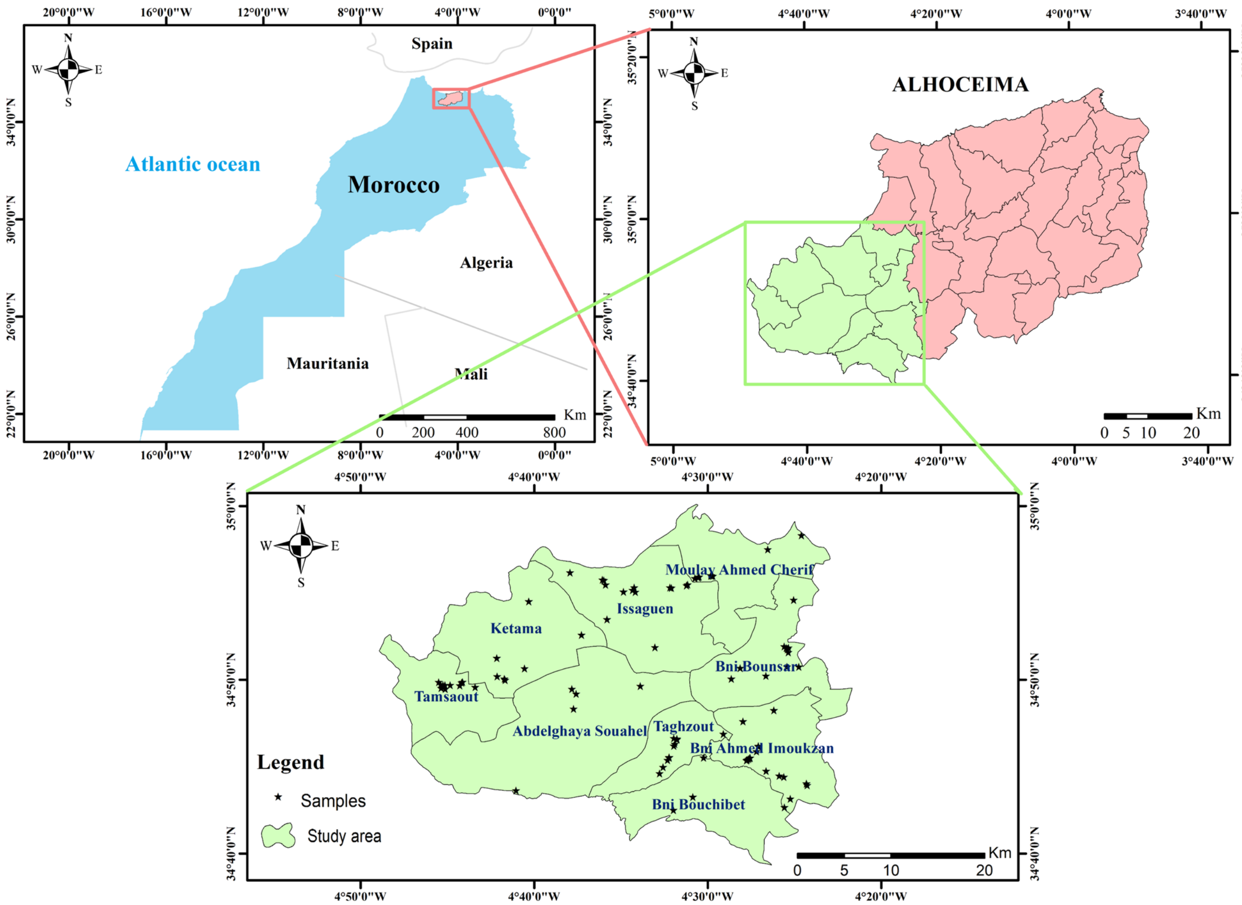

Fig. 1 Study area and location of sampling points

Fig. 2 Photos of a few watering holes in the study area

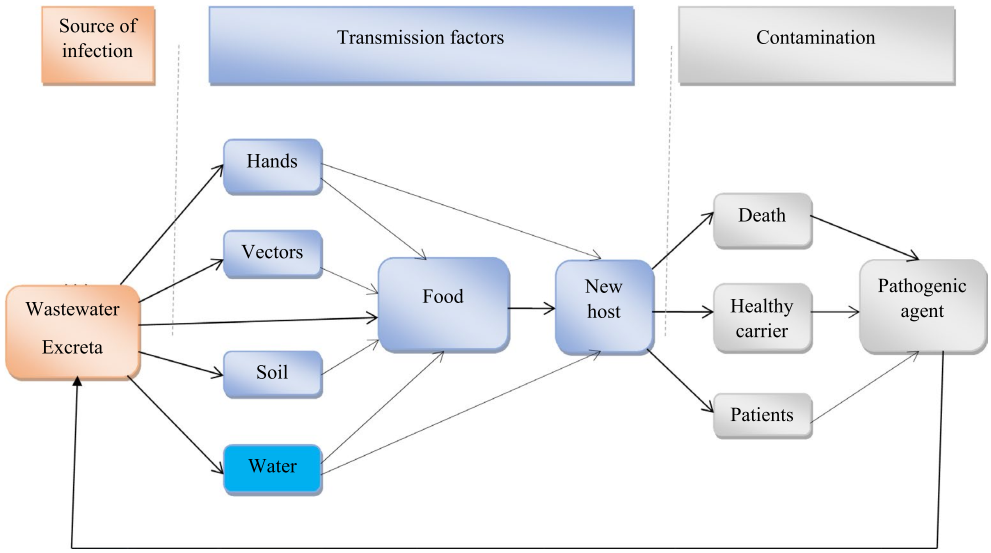

Fig. 3 Modes of disease transmission from wastewater and excreta (Guide 2006)

The coordinates of the sampling points are determined using the global positioning system (GPS: GARMIN GPSmap 62s).

Methods of analysis

Bacteriological parameters

Bacteriological analyses, including total coliforms (TC), faecal coliforms (FC), *Escherichia coli* (*E.coli*), and faecal streptococci (FS), were carried out by filtering 100 ml of the sample through a 0.45 µm pore size membrane, assisted by a vacuum pump, by ISO 9308-1: 2000 and NM 03.7.003. Filters were aseptically deposited on sterile Petri dishes containing a specific culture medium. TC were analyzed using tergitol 7-TTC, and the Petri dishes were incubated in a thermostated oven for 48 h at 37 °C. For *E. coli* quantification, membrane filters were placed on tergitol-TTC and incubated for 48 h at 44 °C. In comparison, FS was grown on Slanets and Bartley medium and incubated for 48 h at 37 °C. Filtration tests were carried out with and without dilution (10^{-1}, 10^{-2}, 10^{-3} dilutions were applied). Analyses are repeated three times for reliable results. The samples were analyzed within 24 h of sampling.

Results in colony-forming unit (CFU) /100 ml of water samples analyzed.

$$CFU/(100mL) = \frac{(Number\ of\ colonies)}{Volume\ of\ water\ filtered\ (100mL)} \quad (1)$$

Table 1 Methods used for physicochemical analyses of groundwater (Rodier et al. 2009)

Parameters	Methods of analysis
pH	InoLab pH 7111
Electrical conductivity (EC, µS/cm)	Hanna HI98311
Total dissolved solids (TDS, mg/l)	
Nitrate (NO_3^-, mg/l)	Spectrophotometer UV (type: RYLEIGH UV-9200)
Bicarbonate (HCO_3^-, mg/l)	Volumetric titration with HCl

Physicochemical parameters

The physicochemical analysis is detailed in Table 1 and was carried out according to the Jean Rodier method (2009) as follows:

Electric Conductivity (EC), Total Dissolved Solids (TDS), and Hydrogen potential (pH) were determined during collection. Nitrates (NO3-) (ISO 7890-3), bicarbonates (HCO3-) by volumetric determination with hydrochloric acid (HCl) (NF EN ISO 9963-1).

Data processing

Statistical analyses were conducted using XLSTAT version 2016 (minimum, maximum, mean, and standard deviation), Excel to produce the graphs, and ArcMap 10.8 to produce the maps Table 1.

Table 2 Parameters of the model for assessing the health risks posed by excessive levels of nitrates in groundwater in the region of Ketama

Parameters	CF ($L.cm^{-2}$)	ET ($h.d^{-1}$)	EV	K_P ($cm.h^{-1}$)	SA (cm^2)	AT (d)	BW (kg)	ED (a)	EF ($d.a^{-1}$)	IR ($L.d^{-1}$)	D_{Rf} ($mg.kg^{-1} d^{-1}$)
Significations	Volume conversion factor	Bath duration	Frequency of bathing	Skin permeability coefficient	Skin contact surface area	Life expectancy of residents	Weight of residents	Duration of exposure	Frequency of exposure	Rate of water consumption	Reference dose of a particular non-carcinogenic substance in water
Infants	0.001	0.4	1	0.001	0.5×10^4	365	6.9	>1	365	0.5	1.6
Children	0.001	0.4	1	0.001	1.2×10^4	4 380	18.7	12	365	0.78	1.6
Adults males	0.001	0.4	1	0.001	1.6×10^4	28 032	65	76.8	365	2	1.6
Adults females	0.001	0.4	1	0.001	1.5×10^4	28 689	55	78.6	365	2	1.6

Nitrate health risk assessments

The health risk assessment approach uses quantitative analysis to determine how hazardous water contaminants affect human health. The assessment model integrates risk characterization, exposure assessment, dose–response analysis, and hazard identification (Liu et al. 2021; Alimohammadi et al. 2018). The widely respected methodology of the United States Environmental Protection Agency (US Environmental Protection Agency 2011) was used in the current study to assess the threat of nitrates to human health in groundwater in the Ketama region. The non-carcinogenic health risk was calculated by Eqs. from (2) to (5):

$$HI = \frac{I_{CD}}{D_{Rf}} \tag{2}$$

The non-carcinogenic risk (HI) threshold proposed by the USEPA is 1.

- HI < 1: the non-carcinogenic health risk is acceptable.
- HI ≥ 1: the non-carcinogenic health risk is unacceptable (Adimalla and Qian 2019; Narsimha and Rajitha 2018; USEPA 1997, 2002).

$$I_{CD} = I_{CDI} + I_{CDD} \tag{3}$$

I_{CD} (mg.kg^{-1} d^{-1}): daily exposure dose.
I_{CDI} (mg.kg^{-1} d^{-1}): daily exposure dose through drinking contact.
I_{CDD} (mg.kg^{-1} d^{-1}): daily exposure dose through skin contact.

NO_3^-, the main protagonist, enters our body through two main channels. The first is by drinking water with a high concentration of NO_3^-, and the second is by coming into contact with water polluted by NO_3^-, which can happen through the skin (Liu et al. 2021; Yuan et al. 2020).

$$I_{CDI} = \frac{C \times IR \times EF \times ED}{BW \times AT} \tag{4}$$

$$I_{CDD} = \frac{C \times SA \times K_P \times EV \times ET \times EF \times ED \times CF}{BW \times AT} \tag{5}$$

C (mg.L^{-1}): nitrate concentrations in groundwater.
Table 2**,** Contains the meaning and values of the different parameters used to calculate the non-carcinogenic status of nitrates Table 3.

in groundwater in Ketama (Liu et al. 2021; Adimalla and Qian 2019, 2021b; USEPA 1997, 2002, 1989).

Results and discussion

Bacteriological analysis

Generally speaking, the bacteriological quality of groundwater in the Ketama region shows significant spatial variation, depending on whether or not there are potential sources of contamination in the vicinity of the water points (wells, boreholes, springs).

The presence of microorganisms such as bacteria, protozoa, and viruses in water is a scientific observation and a crucial indicator of water quality and safety (Boujnouni et al. 2022).The detailed analysis of these microorganisms and their concentrations are provided in Table 3. This underscores the significance of our report and the need for immediate action to address the water quality issue.

Groundwater in the Ketama region has moderate to significant bacterial pollution of human and/or animal origin, characterized by a high number of total and fecal coliforms, *Escherichia Coli*, and faecal streptococci. The consumption of these waters could pose a health risk for the region's population, especially children and the elderly, who have weak immune systems. Most water-borne bacterial pathogens infect the gastrointestinal tract and are excreted in the feces of contaminated humans and animals. Water intended for human consumption must not contain microorganisms of fecal origin (Ghalit et al. 2017).

Total coliforms (TC): The total coliforms vary from 0 to 20000 CFU/100 ml, with an average of 683 CFU/100 ml; 80% of the samples are non-compliant for total coliforms. The spatial distribution (Fig. 4a) shows that the maximum values are observed at the Ketama, Issaguen, and Abdelghaya Souahal communes.

Fecal coliforms (FC): The number of fecal coliforms varies from 0 to 2500 CFU/100 ml, with an average of 27 CFU/100 ml. 50% of the samples are non-compliant for fecal coliforms. The spatial distribution (Fig. 4b) shows that the maximum values are observed at Taghzout, Issaguen, and Abdelghaya Souahal communes.

Escherichia coli (E. coli) are widely used to monitor drinking water quality, are present in significant numbers in human and animal faeces, and are rarely found without faecal pollution (Ghalit et al. 2017). The number of *E. coli* varies from 0 to 2000 CFU/100 ml, with an average of 20 CFU/100 ml, and 35% of the samples are non-compliant with *E. coli*. The spatial distribution (Fig. 4c) shows that the maximum values are observed at Taghzout, Issaguen, and Abdelghaya Souahal communes.

Faecal streptococci: The presence of enterococci in groundwater indicates fecal contamination of groundwater. This contamination could be due to diffusion by

Table 3 Statistical description of bacteriological parameters in groundwater and description of the various bacteria (NM03.7.001. 2006)

Parameters	Faecal streptococci	*Escherichia coli*	Fecal Coliforms	Total Coliforms
Min	0	0	0	0
Max	1200	2500	2500	20000
Average	38	20	99	##
Standard deviation	##	##	##	##
MAV*	0 CFU/100 mL	0 CFU/100 mL	0 CFU/100 mL	0 CFU/100 mL

* *MAV* Maximum admissible value

* Moroccan standard 03.7.001

infiltration or lateral diffusion through the porosities of the soil of the soiled waters, their runoff (because these wells do not meet the construction standards), or direct contamination of the water table by soiled objects (Moussima Yaka et al. 2020).

The number of faecal streptococci varies from 0 to 1200 CFU/100 ml, with an average of 13 CFU/100 ml; 36% of the samples are non-compliant for faecal streptococci. The spatial distribution (Fig. 4d) shows that the maximum values are observed in the Issaguen and Abdelghaya Souahal communes.

80% of the samples do not comply with Moroccan standard 03.7.001, and only 20% comply. These results are justified by the absence of a sewage system in the study area and the existence of septic tanks that are, in most cases, in the perimeter of protection of water points and sometimes upstream of water points; the majority of water points are undeveloped (Fig. 5) which promotes human and/ or animal faecal contamination of these waters.

25%, 12.5%, and 63.64% of water points comply with Moroccan regulations for wells, springs, and boreholes respectively, while 75%, 87.5%, and 36.36% of water points are non-compliant for wells, springs, and boreholes respectively (Fig. 5).

Well and natural spring water raises concerns about the health of the population. Biological contaminants (bacteria, parasites, viruses) and chemical pollutants can seep into groundwater (wells, springs), which is a danger for their use for drinking and/or food preparation (OMS 2016). This can lead to more or less serious diseases and epidemics if these waters are not controlled, especially in rural areas where septic tanks are dominant, which is a major source of contamination of the water table. In rural Morocco, only 2.9% of the population uses a domestic system, 49.2% evacuates wastewater to septic tanks, and 47.9% to lost wells or directly to nature (OMS 2016).

80% of groundwater samples taken in the 9 municipalities of the study area and intended for human consumption were contaminated with fecal contamination germs and other origins present more or less significant concentrations of total coliforms, fecal coliforms, *E. coli*, and fecal streptococci. These contaminants could threaten users' health, particularly the elderly, vulnerable people, and children, exposing the population to water-borne diseases.

According to current regulations, no germs must be present in 100 ml of water to be drinkable and present no health risk.

The presence of faecal coliforms, *E. coli*, and faecal streptococci in the groundwater of the various communes in the study area may be linked to the manure, pits, and solid waste around water points. Contamination is more pronounced in water from wells and undeveloped springs (without any means of protection such as curbstone, casing, cover, or platform). The removal of water using an unsuitable and abandoned seal from the ground further promotes contamination of well water.

For Abdelghaya Souahal, Moulay Ahmed Cherif, and Bni Ahmed Imougzen, the concentration of faecal streptococci in groundwater is higher than *E. coli* and is likely residual contamination as faecal streptococci survive longer in the environment.

This contamination presents health risks for the inhabitants of the study area, especially the elderly, pregnant women, and children under 5 years old/5 years of age because it is the most vulnerable age group to diarrhoeal diseases.

Several studies have discussed the impact of contaminated water consumption on human health (Rabearisoa et al. 2024; Moussima Yaka et al. 2020; Diakite Fl et al. 2018).

According to the WHO, 88% of diarrhoeal diseases are related to polluted water, inadequate sanitation and inadequate hygiene (Adimalla et al. 2018).

It should be noted that in epidemiological studies (Diakite Fl et al. 2018; Koné et al. 2014), examination of

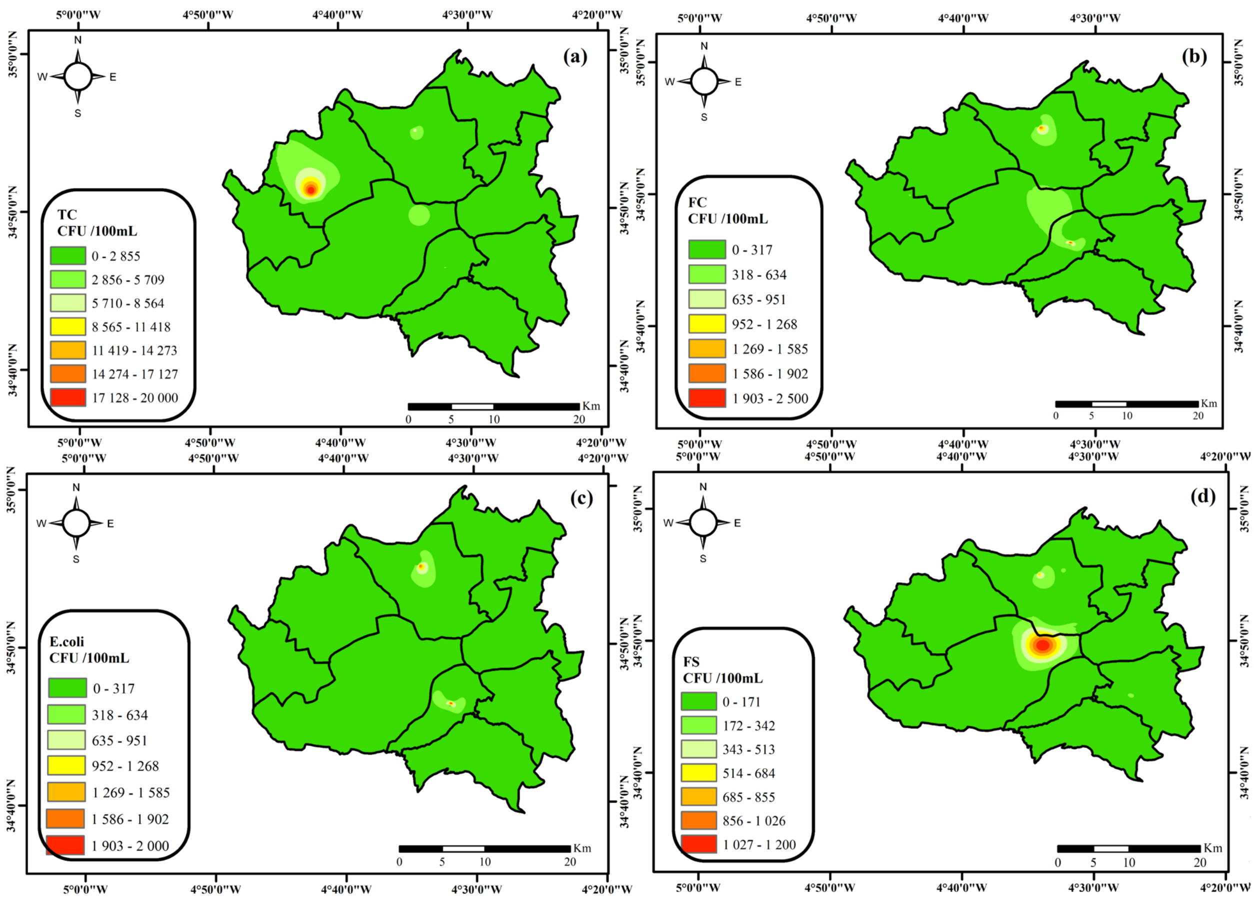

Fig. 4 Spatial distribution of fecal bacteria in groundwater in the Ketama region

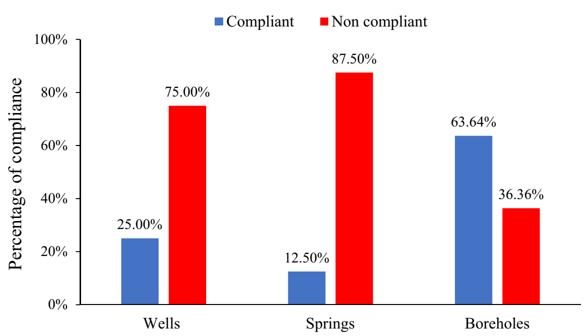

Fig. 5 Percent compliance of water samples by water point type

the relationship between exposure to waterborne pathogens and disease may be complicated by multiple factors that decline into physical factors (solid and liquid waste in the environment), biological (micro-organisms) and social (household income, level of education, supply of drinking water, hygiene and sanitation in the household).

Physicochemical analyses

- The **pH** of groundwater in the Ketama region varies between 5.81 and 8.5, with 12.16% of samples not complying with the regulations (WHO). A non-compliant value can affect the taste, mucosa, and water supply system.
- Conductivity measurements provided an estimate of water mineralization. **EC** groundwater in the Ketama region varies between 32.7 and 1580 µS cm^{-1}, as shown in Table 4. The groundwater studied showed low mineralization.
- **TDS** varies between 27.51 and 1132.86 mg/L; the results show that groundwater in the study area is poorly mineralized (98% of samples with TDS less than 1 g/L). High concentrations may contribute to gastrointestinal irritation.
- HCO_3^- varies from 12.2 to 506.3 mg/L. It's important to be aware that drinking water with a high content of HCO_3^- can have a significant laxative effect, indicating the need for immediate action.

Table 4 Statistical description of the physicochemical parameters of groundwater and their impact on health

Parameters	HCO_3^-	NO_3^-	TDS	EC	pH
Unit	(mg/L)	(mg/L)	(mg/L)	$\mu S \cdot cm^{-1}$	–
Range of results	12.2–506.3	0–146.10	27.51–1132.86	32.7–1580	5.81–8.5
Number of Non-compliant samples	2	22	–	1	20
% of Non-compliant samples	1.21	13.41	–	0.6	12.16
DL	–	–	500	–	6.5
MAL	500	45	2000	1500	8.5
Adverse impact if chemical concentration exceeds MAL *	Laxative effect	Methaemoglobinaemia in bottle-fed newborns	Gastrointestinal irritation	Laxative effect	Effects of taste, mucous membrane and water supply system

* WHO 2017; Yuan et al. 2020)

DL: Desirable Limit, MAL: Maximum Allowable Limit

Assessment of nitrate health risk

NO_3^- varies between 0 and 146.1 mg/L, with 13.41% of samples being non-compliant. A high concentration of drinking water may contribute to methemoglobinemia in bottle-fed newborns.

Excessively high concentrations of nitrate are dangerous to public health, as they can cause methemoglobinaemia in children, stomach cancer in adults, diabetes, and thyroid hypertrophy. (Moussima Yaka et al. 2020; Diakite Fl et al. 2018).

Children are particularly vulnerable to the adverse health effects of exposure to chemicals, such as exposure to NO_3^- through ingestion, due to the weakening and development of their immune systems (Ernesto et al. 2014; Richard et al. 2014).

The non-carcinogenic risks of nitrates in drinking water are not limited to a specific region. They are a global concern, particularly in areas where the majority of the population relies solely on groundwater for drinking without any water quality checks (Hou et al. 2023). This global perspective underscores the wider implications of the issue.

The health risk assessment in the Ketama region reveals a concerning picture. The Hazard Index (HI) for infants, children, adult men, and adult women ranges from 0 to 6.64, 0 to 3.83, 0 to 2.81, and 0 to 3.33, respectively. Alarmingly, 32%, 18%, 10%, and 15% of groundwater samples exceed the acceptable non-carcinogenic risk for infants, children, adult men, and adult women, respectively. Similar results have been discussed and proven by other previous studies (Liu et al. 2021; Adimalla and Qian 2021b; Ravindra et al. 2019; Singh et al. 2020).

Figure 6 shows the results of the health risk assessment of nitrates in groundwater in the Ketama region for adult women, adult men, and children Fig. 7.

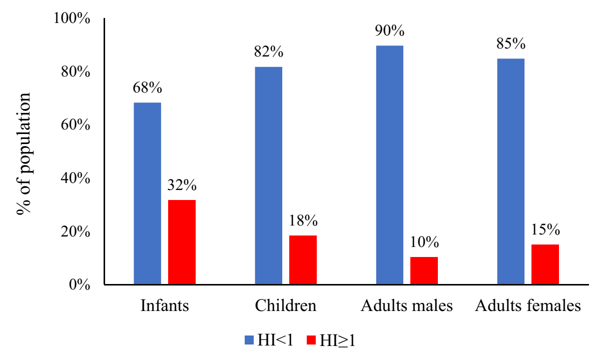

Fig. 6 The distribution of the percentage of the non-carcinogenic risk from groundwater in infants, children, adult males, and females

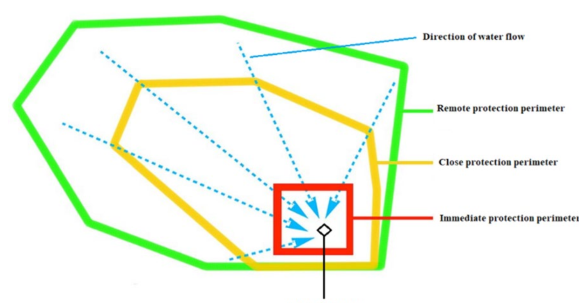

Fig. 7 Perimeter protection of a water point

Several studies have shown that groundwater nitrate pollution is mainly caused by human activities, such as the discharge of poor-quality domestic and industrial wastewater, agricultural fertilizers, and runoff water (Su et al. 2021).

Health can be threatened when nitrate levels in groundwater exceed acceptable levels (Stanly et al. 2021).

Limiting threats to human health is extremely important, as nitrate contamination of groundwater is not just a matter of concern but essential to the safety of drinking water.

Measures to protect groundwater quality

Based on these findings, protective measures must be taken to protect and preserve the groundwater of the Ketama region from further contamination.

Measures to protect and improve water quality require awareness campaigns with all stakeholders, including:

- **Location:** sources of pollution should be located as far as possible from the location of water points (wells, boreholes, springs).
- **Hydrogeological studies** must be conducted to verify the nature of the nature of the soil (porosity and permeability), the topography, the direction of groundwater flow, and the depth of the water table before choosing the location of a water point (Ezugwu et al. 2019).
- **Scope of protection:**
- Immediate perimeter: to protect equipment deterioration and prevent pollutants from entering the water point;
- Close perimeter: to protect water catchment from underground migration of pollutants;
- Remote perimeters are created when there is a risk of pollution that cannot be safely reduced by the land's nature (Guide « hygiène et assainissement communautaires », ministère de la santé, direction de l'épidémiologie et de lutte contre les maladies 2006). The concept and implementation of these protection perimeters are visually represented in Fig. 7.
- **Equipment:** Each water point must have fixed extraction equipment to facilitate extracting water and preserving its quality.
- **Maintenance:** Each water point requires regular maintenance (cleaning, cleaning, disinfection).
- **Disinfection:** To minimize the risk to public health, groundwater must be treated before consumption.
- Farmers must use biodegradable fertilizers, insecticides, and herbicides instead of non-biodegradable products (Ezugwu et al. 2019).
- Regular IEC (Information, Education, and Communication) sessions on population health and hygiene.

Conclusion

The preliminary study, which assessed the health risks associated with groundwater quality in the Ketama (intrarif) Morocco region, evaluated the bacteriological and physicochemical quality of the water consumed by the region's population. Data from the analyses revealed worrying indications of potential exposure for residents. Groundwater contamination by fecal germs, notably total coliforms, fecal coliforms, E. coli, and fecal streptococci. Slightly acid pH, low mineralization indicated by conductivity, TDS, and nitrate concentration exceed WHO drinking water guidelines. The nitrate health risk assessment clearly shows that infants and children in the study area are more likely to be exposed to health risks than adult men and women.

Emphasis should be placed on practical provisions through education and awareness-raising among the population of the Ketama region on good hygiene practices and groundwater disinfection methods, as greater population awareness would necessarily reduce the frequency of water-borne diseases.

Acknowledgements
The authors thank the local residents who gave us permission to collect water samples on their properties.

Author contributions
Each author played an essential role in the development of the work, contributing significantly to its conception, drafting and revision. In addition, all authors reviewed the final version of the manuscript and gave their approval. In Summary, RE: Data curation, Writing-original draft. MG: Methodology, Investigation. MA: Supervision. SE: Validation. SJ: Writing-review & editing. AM: Investigation. KA: Validation.

Funding
This work was not funded by any project.

Availability of data and materials
The datasets used for the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no conflict of interest.

Received: 22 May 2024 Accepted: 16 July 2024
Published online: 13 August 2024

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