Original Research Article

Study of chemical and microbiological pollutants in water from certain wells and boreholes in the town of Koudougou, Burkina Faso

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ABSTRACT

Aims: Market gardening in the vicinity of water bodies has an impact on groundwater quality. This study assessed the chemical and microbiological pollution of groundwater in the town of Koudougou, Burkina Faso.
Study design: To this end, water samples were taken from wells and boreholes near watercourses and in market garden production areas.
Place and Duration of Study: Well and borehole water samples were taken in the town of Koudougou during December 2023. Analyses were carried out at the Laboratory of Analytical Chemistry, Space and Energy Physics (L@CAPSE) in December 2023, and at the National Agency for Environmental, Food, Labor and Health Product Safety (ANSSEAT) in Ouagadougou in January 2024. The study ran until November 2024.
Methodology: Physico-chemical analyses were carried out according to standard methods and water quality standards in force in Burkina Faso. Principal Component Analysis was carried out using XLSTAT software, and hydrochemical facies analysis was carried out using Diagram software from the Hydrogeology Laboratory of the University of Avignon. The extraction of pesticides from the water was adapted to the QuEchERS method, and bacteria were detected by filtration on cellulose membranes.

Results: The results of principal component analysis of the water samples revealed strong correlations between Ca^{2+} and Mg^{2+} (0.98), Al^{3+} and Fe^{2+} (0.96), Cl^- and Na^+ (0.93), NO_3^- (0.80). Thus, the origin of the chemical elements could be explained by direct infiltration of surface water and the influence of anthropogenic activities. Analysis of the hydrochemical facies reveals anthropogenic pollution. In addition, the high Al^{3+} content in some wells is partly linked to rock weathering. In addition, pesticide residue levels have been found to exceed standards. The water shows faecal contamination, with total coliform levels reaching 800 CFU/100 mL.

Conclusion: All in all, well water as a whole and 60 % of borehole water were found to be unfit for human consumption.

Keywords: Vegetable growing; chemical pollutants; pesticides; well water; drilling.

1. INTRODUCTION

Water is the source of life. Indeed, it is the main constituent in many of society's activities, including domestic, agricultural, industrial, energy production and mining activities. As a result, the need for water is increasing due to high consumption linked to demographic growth and the needs of competing economic sectors (Huffman, 2014).

However, water must be available in sufficient quantity and quality for economic and sanitary stability. Unfortunately, it has to be said that water is not available in sufficient quantity and quality in some parts of the world. In 2017, 435 million people had no access to drinking water (OMS, 2019). Although it may be insufficient, it can also be polluted.

Water pollution can be linked to a number of factors, such as industrial activities and increasing urbanization. However, agriculture remains the main source of water pollution (Harrison, 2002). In agriculture, many chemicals are used to increase yields and facilitate farming practices. Unfortunately, these chemicals can leach into groundwater at high levels, with harmful consequences for consumers.

In Burkina Faso, agriculture, which is practiced by over 80 % of the population, represents the country's main economic activity, with the corollary of significant use of fertilizers and pesticides. The quantity of pesticides used in 1997 was estimated at around 2,533 tones, with an annual growth rate of 11 % (PGPP, 2021). The abusive and uncontrolled use of harmful chemicals in this sector, especially in market gardening, can have a very negative impact on the quality of surface water, as well as well and borehole water.

The town of Koudougou, like many other towns in Burkina Faso, is no exception. Indeed, market gardening occupies a significant proportion of the population. These crops are grown to satisfy a growing demand, while improving the subsistence economy of many households. However, many households consume water from wells and boreholes located close to the cultivation areas in the city. This raises questions about the quality of this water. To this end, various physico-chemical and microbiological analyses were carried out on water samples (from wells and boreholes) to determine the extent of pollution.

2. MATERIAL AND METHODS

2.1. Location of study area and sampling points

The urban commune of Koudougou, capital of the Centre-Ouest region, is located 100 km from Ouagadougou, the capital of Burkina Faso. It lies between 2° 21' 51'' West Longitude and 12° 15' 3'' North Latitude (PCD, 2018). The research focused on water from five wells and five boreholes located in different sectors (1, 3, 5, 8 and 10) of the city. Figure 1 shows the location of the wells and boreholes by sector, as well as the geology of the commune.

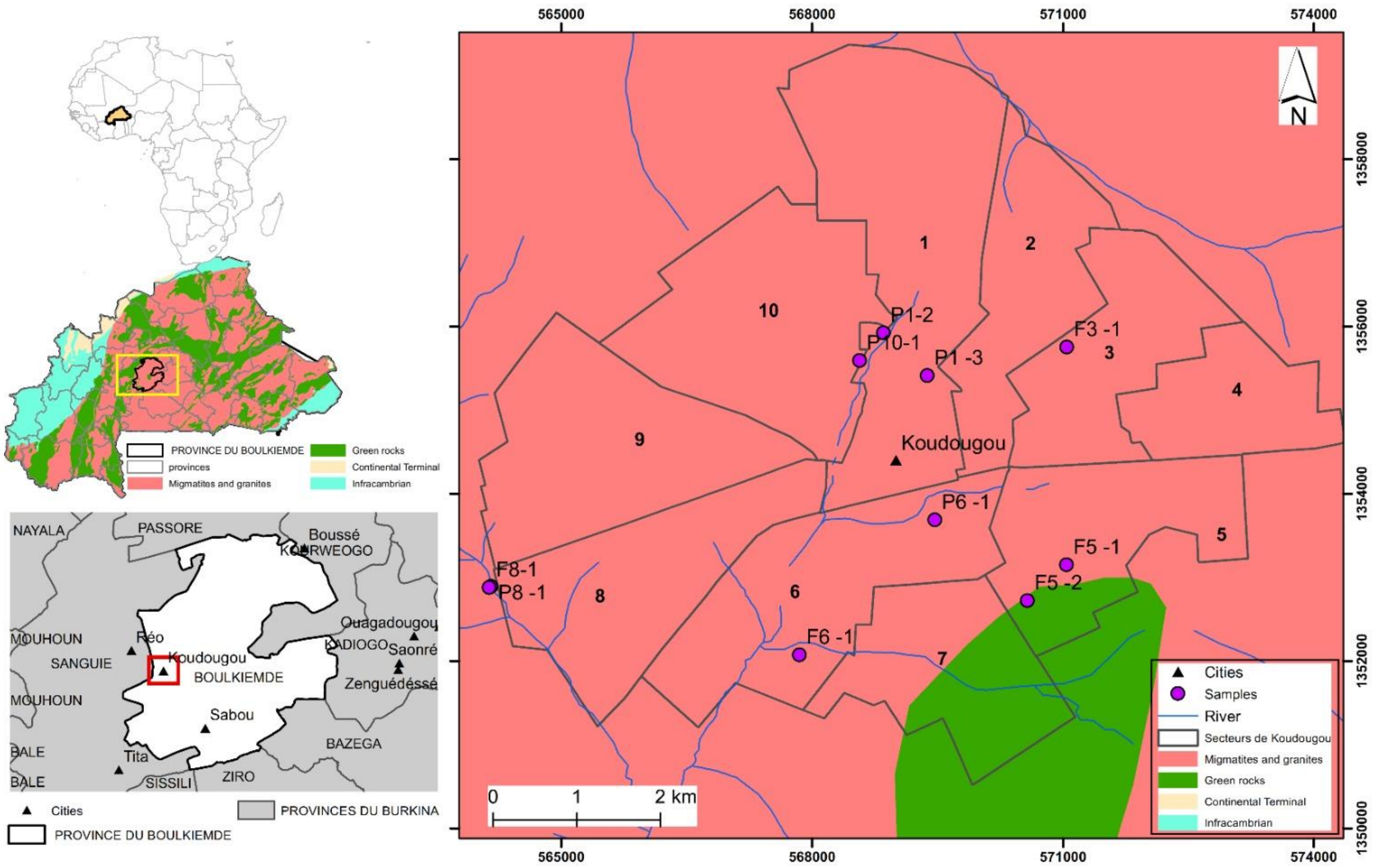


Fig.1. Location and geological map of the study area

2 .2. Sample analysis

2.2.1. Analysis of physico-chemical parameters

Sampling was carried out in accordance with French standards NF EN ISO 19458 and NF EN ISO 5667-3, during December 2023. The water samples used for ion analysis were taken in one-liter polyethylene tubes. pH, dissolved oxygen, temperature, electrical conductivity (EC) and turbidity were measured in situ, while major ions, dissolved metals (aluminum, iron), fluoride, hydrometric titre (TH) and total hardness were measured in the laboratory.

Physico-chemical analyses were carried out in accordance with standard methods and water quality standards in force in Burkina Faso. The concentration of calcium ions Ca^{2+}, magnesium ions $Mg^{2+,}$ chloride ions Cl^{-}, and total hardness or hydrotimetric titre (TH) were determined using the volumetric method. Iron ($Fe^{2+),}$ aluminum (Al^{3+}), nitrates (NO_3^{-}), nitrites (NO_2^{-}), sulfates (SO_4^{2-}) and fluorides (F^{-}) were determined by molecular absorption spectrophotometry using the HANNA “Multiparameter Photometer HI 83300”.

2.2.2. Pesticide analysis

The water samples used for pesticide analysis were taken in one-liter glass vials, then analyzed at the Agence Nationale pour la Sécurité Sanitaire de l'Environnement, de l'Alimentation, du Travail et des Produits de Santé (ANSSEAT). The extraction of pesticides from water was adapted to the QuEchERS method proposed by Standard NF EN 15662 of 01/2009. Separation, identification, quantification and confirmation of pesticide molecules were carried out using an Agilent 6890N gas chromatograph coupled to an Agilent mass spectrometer. The system is controlled by a computer running Cheamstation software for data acquisition and processing.

2.2.3. Microbiological analysis

Samples for microbiological analysis are taken in sterilized 250 mL glass vials. In order to avoid changes in the initial germ content of the water, samples are stored immediately in a cooler at a temperature below 4°C during transport to the laboratory. All this was done to comply with the instructions set out in standards NF EN ISO 19458 (November 2006) and NF EN ISO 5667-3 (June 2004).

Bacteria are detected by filtration on cellulose membranes. Culture media are prepared in advance and poured into Petri dishes. Bacteriological parameters tested and enumerated included fecal coliforms (FC), Echérichia colis (E. colis), total coliforms (TC) and fecal streptococci (FS), in accordance with the AFNOR standard described in Rodier (2009).

2.2.4. Statistical analysis

Principal Component Analysis (PCA) was performed using XLSTAT 2016.02.28451. PCA is used in the field of water (Kafando, et al., 2021, Rezouki, et al., 2021, Ibrahima Oumarou, et al., 2022) and is an extremely powerful tool for synthesizing information (Guerrien, 2003). Hydrochemical facies analysis was carried out using Diagram software from the Hydrogeology Laboratory of the University of Avignon.

3. RESULTS AND DISCUSSION

3.1. Results

Table 1. Analytical results for physicochemical parameters of well and borehole water

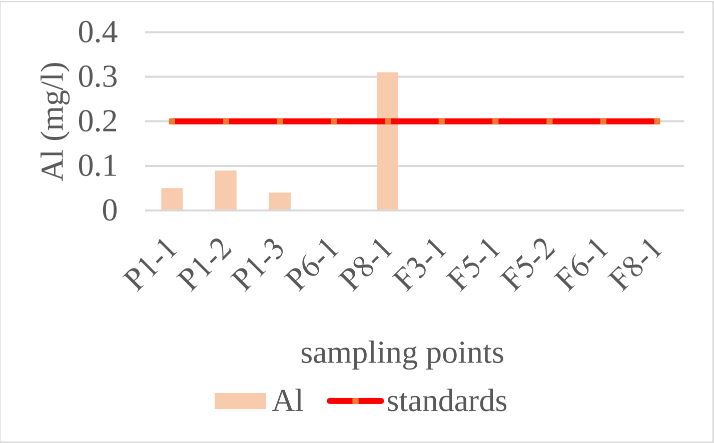
Parameters	Units	P10-1	P1-2	P1-3	P6-1	P8-1	F3-1	F5-1	F5-2	F6-1	F8-1	Guide value
pH	-	5,94	6,07	6,02	5,92	7,14	6,32	7,34	7,04	6,88	6,37	6,5-8,5
T°C	ºC	29,3	26,6	25,6	35	35	32	35,5	29,8	28,6	28,9	-
CE	µs/cm	275	248,5	542	844	163,5	189,6	596,7	567,6	249,2	223	2000
TH	mg/L	222,11	163,66	450,06	672,17	134,43	233,8	806,61	777,38	286,4	263,02	-
TAC	mg/L	140	90	90	110	200	200	630	440	290	280	-
HCO_3^-	mg/L	66	35	59	64	83	94	329	233	152	119	-
Cl^-	mg/L	21,9	23	43,4	97,2	5,2	0	4,3	7,4	0,8	1,1	250
NO_3^-	mg/L	6,5	17,9	43,4	35,7	0	0,1	7,8	14,4	0	10	50
PO_4^{3-}	mg/L	0,45	0,27	0,23	0,24	0,41	0,98	0,77	0,47	0,67	0,76	5
SO_4^{2-}	mg/L	7	1	2	2	1	7	4	9	0,0	0	250
F^-	mg/L	0,16	0,07	0	0,08	< LD	0,22	0,46	0,19	0,28	0,35	1,5
Al^{3+}	mg/L	0,05	0,09	0,04	0,0	0,31	0,0	0,0	0,0	0,0	0	0,2
Ca^{2+}	mg/L	81,8	87,7	187,0	32,5	58,5	99,4	379,9	374,4	116,9	122,7	
Fe^{2+}	mg/L	0,00	0,03	0,044	0,00	0,132	0,00	0	0,0	0,0	0,0	0,3
K^+	mg/L	4,7	3,4	3,8	6,0	2,3	1,9	6,5	1,8	3,4	4,4	-
Mg^{2+}	mg/L	140,28	75,99	263,02	350,7	75,98	134,44	426,69	403,3	169,5	140,28	-

LD: detection limit

3.1.1. Aluminum and iron

Analyzed samples show the presence of aluminum in 80% of well waters, with concentrations ranging from 0.04 to 0.31 mg/L (Figure 2). In addition, the water from one of the five wells studied showed concentrations in excess of current national standards, in the order of 0.2 mg/L.

The results reveal the presence of iron in 60 % of the well water analyzed. Concentrations ranged from 0.03 to 0.132 mg/L (Figure 3). However, iron levels in the wells remain within current standards, both for well water and borehole water.



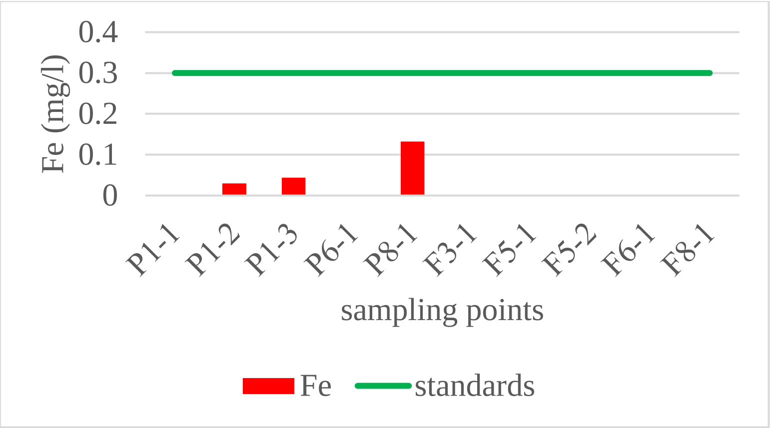


Fig.2. spatio-temporal evolution of Al

Fig. 3. spatio-temporal evolution of iron

3.1.2. Hydrogen potential (pH)

The pH values of the samples measured ranged from 5.92 to 7.34 (Table 1). Most of the water analyzed was acidic (70 %), while the remaining 30 % was slightly neutral. As a result, 60 % of the well and borehole water analyzed was out of specification. There is also a strong positive correlation between pH and TAC (0.82) and HCO_3^- ions (0.80), and negative correlations between pH and Cl^- ions (-0.60) and between pH and NO_3^- ions (-0.55).

3.1.3. Pesticides

Analysis of well and borehole water samples revealed the presence of five different pesticide molecules: Aldrin, Carbofuran, Propanil, Propargite, Triadimefon (Figure 8).

3.1.4. Microbiological analysis

The results of microbiological analysis are reported in Table 2 and show the presence of at least one germ in almost all well and borehole waters, with the exception of P10-1 and F5-1. Total coliforms were the most common, with levels reaching 800 CFU/100 mL.

Table 2. Microbiological analysis results for well and borehole water

Parameters	Units	P10-1	P1-2	P1-3	P6-1	P8-1	F3-1	F5-1	F5-2	F6-1	F8-1	Guide value
CT	UFC/100ml	0	388	800	264	600	3	0	5	49	28	0
CF (E.Coli)	UFC/100ml	0	8	0	10	108	1	0	1	31	12	0
SF	UFC/100ml	0	2	0	0	9	0	0	0	3	0	0

3.1.5. Principal Component Analysis (PCA)

The results of the PCA are shown in Table 3. The analysis reveals both positive and negative correlations between chemical elements. A correlation circle with the F1 and F2 factorial planes was constructed (Figure 4). A factorial design is an experimental design in which two or more independent variables (factors) are studied simultaneously in the same experiment, in order to determine the role of each independent variable, their relative importance and their interaction (unipsed.net).

Table 3. Correlation matrix (Pearson (n))

Variables	pH	CE	TH	DC	TAC	HCO_3^-	Cl^-	NO_3^-	PO_4^{3-}	SO_4^{2-}	F^-	Al^{3+}	Ca^{2+}	Cu^{2+}	Fe^{2+}	K^+	Mg^{2+}	Na^{2+}	TC	FC(E.Coli)	FS
pH	**1,00**																				
EC	-0,07	**1,00**																			
TH	0,32	**0,88**	**1,00**																		
DC	**0,61**	0,37	**0,74**	**1,00**																	
TAC	**0,82**	0,20	**0,62**	**0,84**	**1,00**																
HCO_3^-	**0,80**	0,29	**0,70**	**0,87**	**0,99**	**1,00**															
Cl^-	**-0,60**	**0,73**	0,31	-0,34	-0,49	-0,41	**1,00**														
NO_3^-	**-0,55**	**0,71**	0,39	0,00	-0,39	-0,30	**0,80**	**1,00**													
PO_4^{3-}	0,40	-0,40	-0,06	0,22	0,53	0,48	**-0,68**	**-0,70**	**1,00**												
SO_4^{2-}	0,06	0,16	0,36	0,45	0,27	0,31	-0,14	-0,15	0,21	**1,00**											
F-	0,45	-0,02	0,33	**0,51**	**0,79**	**0,76**	-0,49	-0,47	**0,78**	0,11	**1,00**										
Al^{3+}	0,23	-0,41	-0,49	-0,35	-0,27	-0,32	-0,13	-0,23	-0,33	-0,28	**-0,56**	**1,00**									
Ca^{2+}	0,44	**0,79**	**0,98**	**0,82**	**0,73**	**0,79**	0,16	0,28	0,05	0,33	0,44	-0,49	**1,00**								
Cu^{2+}	**0,54**	0,32	**0,55**	**0,64**	**0,78**	**0,79**	-0,19	-0,14	0,33	0,08	**0,65**	-0,18	**0,59**	**1,00**							
Fe^{2+}	0,23	-0,32	-0,42	-0,28	-0,28	-0,32	-0,08	-0,06	-0,38	-0,35	**-0,62**	**0,96**	-0,41	-0,17	**1,00**						
K^+	-0,16	**0,55**	0,42	0,06	0,20	0,22	0,47	0,33	-0,11	-0,26	0,37	-0,33	0,36	**0,59**	-0,35	**1,00**					
Mg^{2+}	0,30	**0,88**	**1,00**	**0,74**	0,61	**0,69**	0,31	0,40	-0,05	0,37	0,33	**-0,51**	**0,98**	**0,55**	-0,43	0,42	**1,00**				
Na^+	-0,30	**0,85**	**0,52**	-0,09	-0,23	-0,14	**0,93**	**0,78**	**-0,68**	-0,14	-0,40	-0,04	0,39	0,07	0,04	**0,54**	**0,52**	**1,00**			
TC	-0,22	0,07	-0,22	-0,28	**-0,54**	**-0,51**	0,36	**0,57**	**-0,69**	-0,45	**-0,79**	**0,58**	-0,27	-0,26	**0,74**	-0,13	-0,21	0,42	**1,00**		
FC (E.Coli)	0,43	-0,40	-0,43	-0,36	-0,11	-0,17	-0,19	-0,37	-0,12	-0,42	-0,36	**0,89**	-0,38	-0,18	**0,86**	-0,32	-0,44	-0,07	0,41	**1,00**	
FS	0,43	-0,46	-0,48	-0,34	-0,14	-0,19	-0,24	-0,40	-0,17	-0,42	-0,40	**0,91**	-0,44	-0,17	**0,88**	-0,38	-0,50	-0,13	0,44	**0,98**	**1,00**

Table 4 shows the factors with their eigenvalues and the different percentages expressed. The first three factors alone express 80.082 % of the information, including factor 1 with 37.591 %, 26.314 % for factor 2 and 16.177 % for factor 3. The first two factors account for 63.905 % of the total variance expressed. Thus, the F1-F2 pair alone expresses more than 63.905 % of the information. In view of the percentages expressed, the mechanisms controlling the chemical evolution of water are mostly contained in these two factors.

Table 4. Eigenvalues of expressed factors

	F1	F2	F3	F4	F5	F6	F7	F8	F9
Eigenvalue	9,022	6,315	3,883	1,719	1,591	0,714	0,434	0,246	0,077
Variability (%)	37,591	26,314	16,177	7,162	6,631	2,973	1,806	1,025	0,320
% cumulative	37,591	63,905	80,082	87,244	93,875	96,848	98,655	99,680	100,000

3.1.6. Hydrochemical facies

The Piper diagram (Figure 7) shows the different facies derived from the hydrochemical analysis of water from sampled wells and boreholes. This diagram provides a good understanding of water mineralization (Kutangila, et al., 2024) [12].

3.2. Discussion

3.2.1. Principal Component Analysis of well and borehole water hydrochemistry

The positive part of the F2 factor is determined by Cl^-, NO_3^- and Na+ ions (Figure 4). The close proximity of these ions shows their common origin. The correlation between Cl^- and NO_3^- is 0.799. The existence of these two ions in groundwater is attributed, in the case of chlorides, to rainfall from the forest canopy and humus-bearing soils and, in the case of nitrates (NO_3^-), to anthropogenic activities, i.e. the use of fertilizers (SORO, et al.,2019, Koné, et al. 2009). Wells P1-3 (in market-garden areas) and P6-1, which are more closely linked to the F2 factor (Figure 5), are close to bodies of water. Furthermore, the Na/Cl molar ratios in the water from wells P1-3 and P6-1 are all below 0.85, indicating that Na^+ and Cl^- ions are of external origin. Indeed, if the Na/Cl ratio is equal to unity, this would indicate that these two ions originate from the dissolution of evaporites, whereas if the molar ratio is equal to 0.85, Na^+ and Cl^- ions are of marine origin, and a ratio of less than 0.85 indicates some pollution (Kafando, et al., 2021, Müller, et al., 2006, Thomas, et al., 2016). Thus, the presence of Cl^-, NO_3^- and Na^+ ions would probably indicate infiltration of water from bodies of water, domestic effluents and the use of fertilizers and manure in fields. Thus, the F2 factor would express the origin of elements through direct infiltration of surface water and the influence of anthropogenic activities on water quality (Soro, et al., 2019). The negative correlation of PO_4^{3-} with Cl^- (-0.68) and NO_3^-(-0.70) indicates that the increase in chlorides and nitrates in water leads to a decrease in orthophosphates. In addition, the strong negative correlation of F3-1, F8-1 and F6-1 with F2 reveals their common origins and points to a natural occurrence of the chemical elements in these different waters. The Na/Cl molar ratio indicates that the ions (Cl^- and Na^+) in F8-1 and F6-1 have a marine origin. Furthermore, Thomas et al (2016) indicates that the origin of Cl^- and Na^+ may be linked to the dissolution of evaporites.

The F1 factor is correlated in its positive part by the elements $Ca^{2+,}$ Mg^{2+}, K^+ and in its negative part by the ions Fe^{2+} and Al^{3+} (Figure 4). The presence of these elements in groundwater is explained by the alteration of silicate minerals. Through weathering, silicate mineral ions (Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe^{2+}...) are partly replaced by H^+ ions (Thomas, 2010). Furthermore, the weathering of aluminosilicates (notably the feldspars and micas of siliceous rocks, clay and phyllite minerals) releases Al^{3+} ions. From the above, the F1 factor describes the conditions under which mineralization is acquired (Soro, et al., 2019).

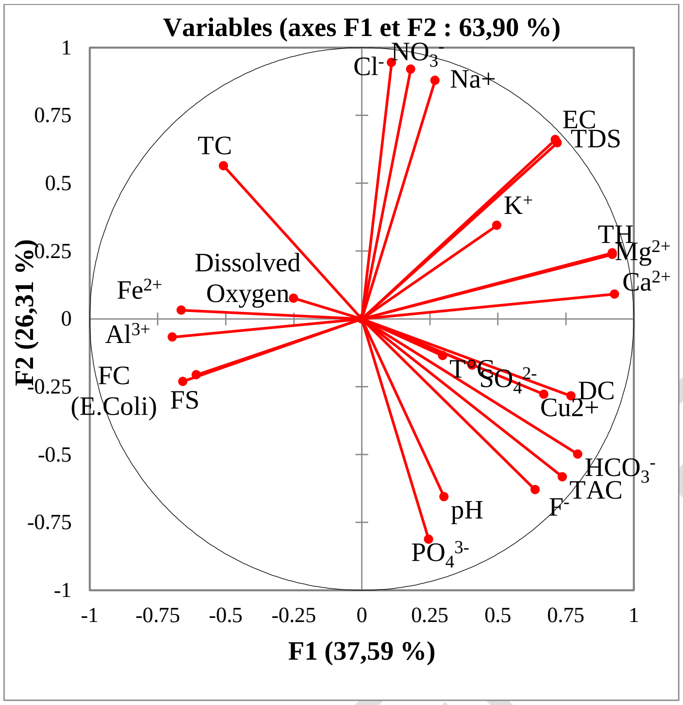


Fig. 4. Correlation circle

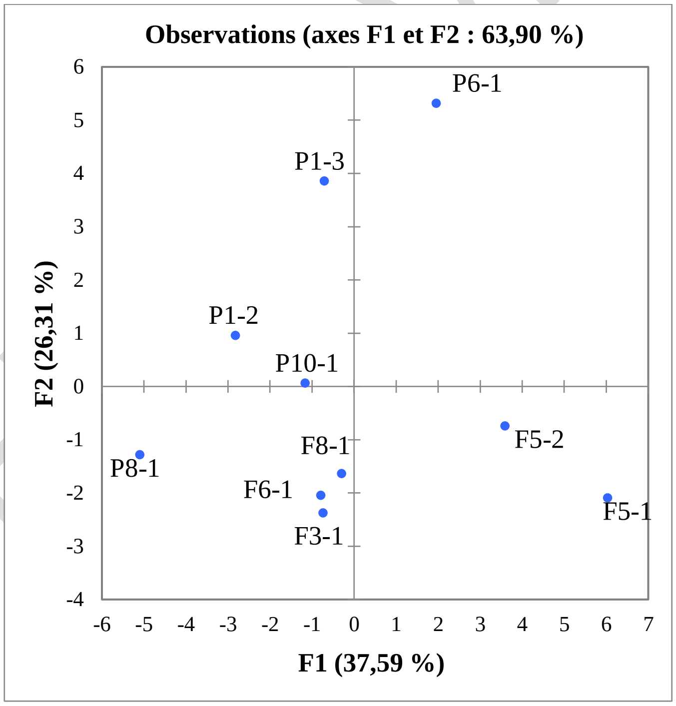


Fig. 5. Representation of wells and boreholes in the F1-F2 factorial plane

FC: faecal coliforms ,FS: faecal streptococci, TC: total coliforms, EC: Electrical Conductivity, TDS: total dissolved solids, TAC: Complete alkalimetric titre pH: Hydrogen potential, Hydrotimetric Titre (TH), calcium hardness, DC: calcium hardness

3.2.1.1. Aluminum and iron

Factor 1 is representative of aluminum Al^{3+}(-0.696) and Fe^{2+}(-0.663). The proximity of these two elements on axis 1 could mean that they are brought into solution by the same chemical mechanism. Furthermore, there is a strong correlation (0.962) between Al^{3+} and Fe^{2+}. This affinity between these ions shows that they are of the same internal origin, linked on the one hand to the existing rocks within the alluvium (Ibrahima Oumarou, et al., 2022) in the sense that the wells where these two chemical elements are present, are located in the same calcic and magnesian bicarbonate facies, and on the other hand, of external origin due to anthropic activities, which is justified by the strong correlation between faecal Streptococcus (SF) and $Al^{3+(}$0.912), Fe^{2+} (0.962).

3.2.1.2. Hydrogen potential (pH)

The average pH value measured was 6.50, showing that the borehole and well waters analyzed were predominantly acidic. The acidic character is thought to be partly linked to the decomposition of plant organic matter (Dibi, et al., 2005) (Matini, et al., 2009), thus promoting the production of CO_2, which in contact with water is responsible for the formation of HCO_3^-. Indeed, the combination of oxygen with the organic matter present in the soil leads to the production of carbon dioxide, which dissolves in water to form carbonic acid according to equation (1) (Dibi, et al., 2005, Matini, et al., 2009):

$$\mathrm{CO_2{+}H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons HCO_3^- + H^+} \quad (1)$$

This reaction is justified by the strong correlation between pH and HCO_3^- (0.80), demonstrating that the latter are the source of the pH nature of the samples measured. The negative correlation of pH with Cl^- (-0.60) and NO_3^- (-0.55) shows that an increase in these ions in the water analyzed leads to a drop in pH, and vice versa. The external input of Cl- and NO_3^- has a strong influence on the acidic character of the water analyzed. Furthermore, the correlation between pH and faecal coliforms (FC), Echerichia coli (E.Coli) (0.43), faecal streptococci (0.43) and with the F2 factor (-0.65) confirms water pollution. With the exception of F3-1, all the well and borehole water samples showing acid pH values below current national standards (Figure 6), are located in areas of market gardening or near a body of water (P6-1).

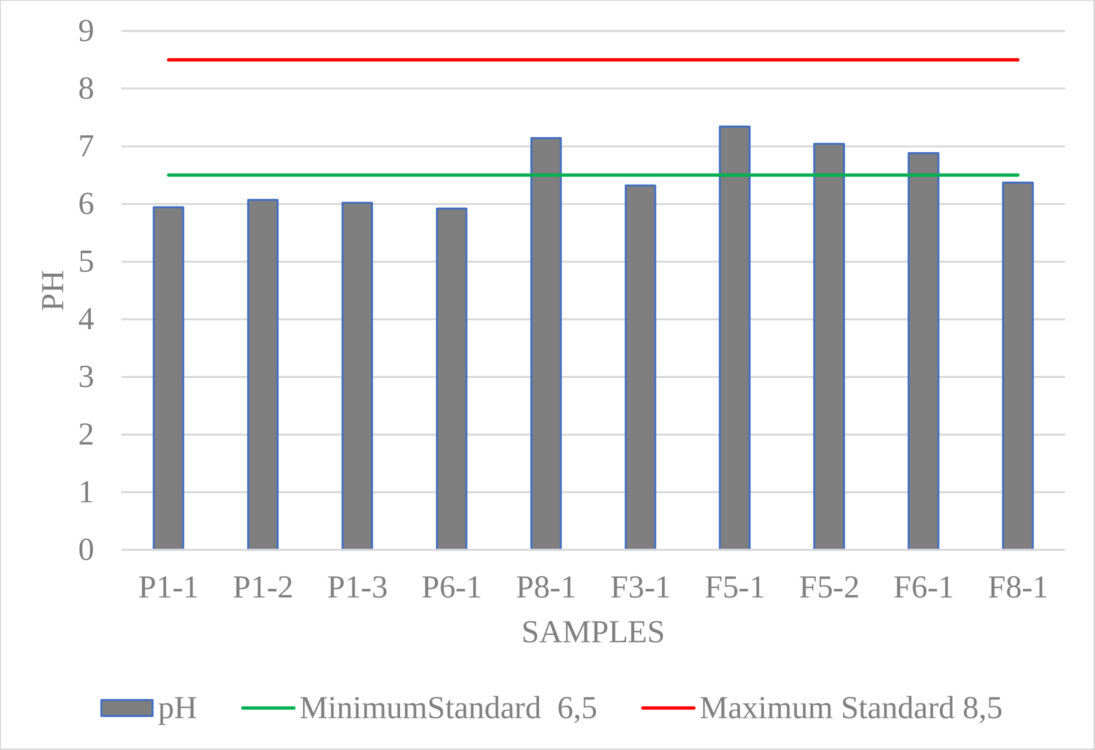


Fig. 6. Spatio-temporal variation in pH

3.2.2. Hydrochemical facies

Calcium and magnesium bicarbonate facies mark the dissolution of carbonate minerals, or the hydrolysis of silicates. Sodi-potassium chloride facies is a marker of anthropogenic inputs (pollution). Chloride-sulfate-calcium-magnesium facies can be considered an intermediate facies between the two.

Figure 7 shows that samples P1-10, P1-2, P1-3 and P6-1 have migrated towards the chloride-sulfate-calcium-magnesium facies. There is therefore a tendency for these samples to become polluted. This pollution can be explained by anthropogenic influences linked to the use of fertilizers or organic manure, and surface water infiltration (Soro, et al., 2019). In fact, several of the above-mentioned water points are located in market-garden cultivation zones and close to bodies of water, which would explain these external inputs.

In addition, the rest of the samples are hosted in the calcium-magnesium bicarbonate facies, reflecting the hydrolysis of silicates with respect to the geology of the study area. Indeed, as shown on the geological map of the study area (Figure 1), F8-1, F6-1, P8-1, F3-1, F5-1 are located in a zone of migmatite rocks and granites, and F5-2 in greenstone. Moreover, the constituent minerals of these migmatite rocks are mainly quartz and feldspar, with the odd micas (Thomas, 2010).

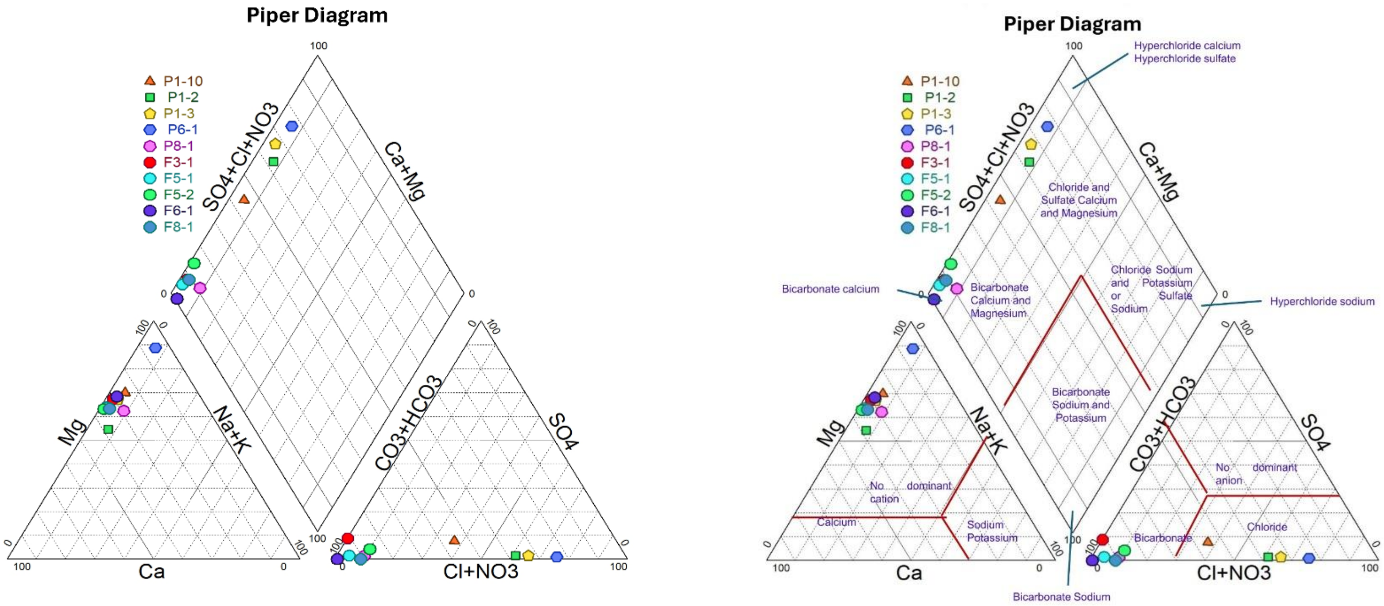
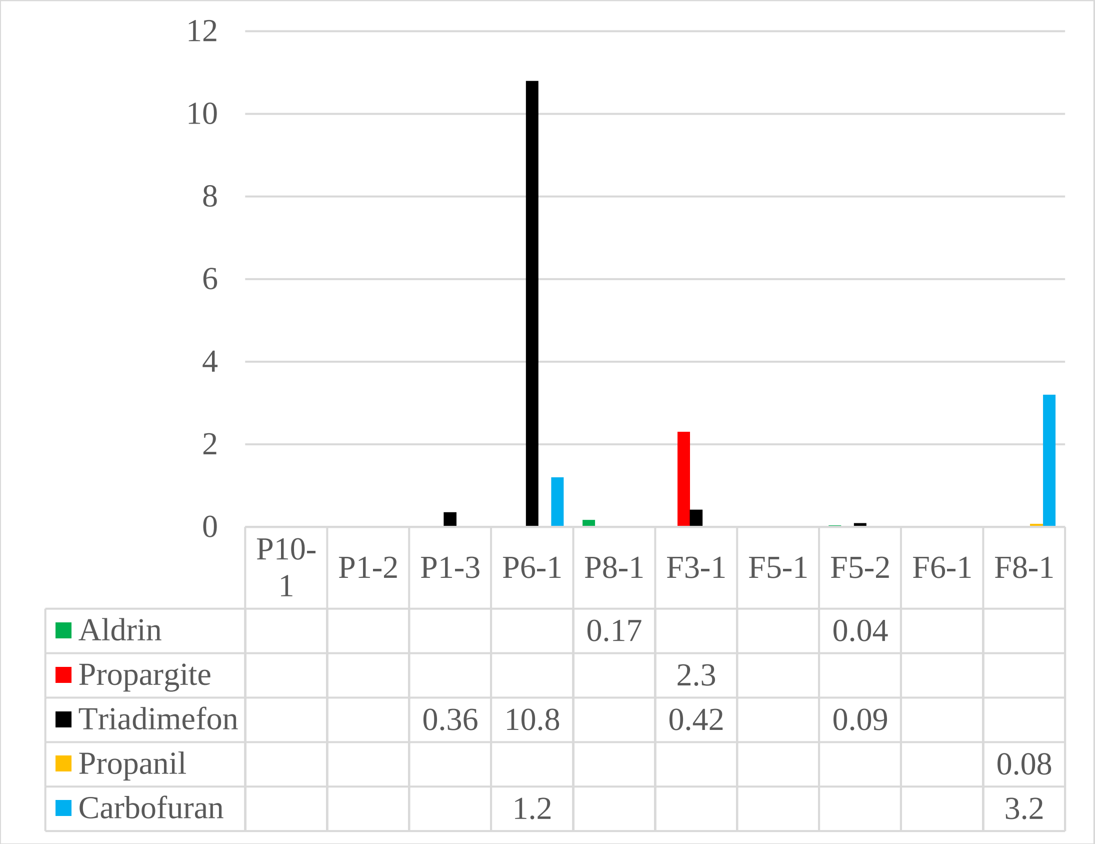


Fig. 7. Piper diagram

3.2.3. Pesticides

The wells and boreholes where pesticides were found are located in areas of high market-gardening activity, with the exception of borehole F3-1. Surveys of market gardeners show that most of them use pesticides (insecticides, herbicides and fungicides). As a result, pesticide pollution of well and borehole water could be explained by the leaching phenomenon (Mylène, 2024). In effect, pesticide residues are carried away by infiltration into the water table. The national guideline value for Aldrin in drinking water is 0.03 µg/L, which shows that pesticide levels in the samples (P8-1 and F2-1) exceed standards. The aldrin content of 0.17 µg/ L in P8-1 is more than five times higher than the current standard of 0.03 µg/ L. The presence of pesticide residues in F3-1 and P6-1 can be explained by the direction of groundwater flow and the infiltration of contaminated surface water. The presence of pesticides in well water could also be linked to the poor management of empty containers after pesticide use, especially as empty containers were noticeable in cultivation areas and often close to wells. Pesticide residues are therefore drained by rainwater infiltration.



	P10-1	P1-2	P1-3	P6-1	P8-1	F3-1	F5-1	F5-2	F6-1	F8-1
🟩 Aldrin					0.17			0.04		
🟥 Propargite						2.3				
■ Triadimefon			0.36	10.8		0.42		0.09		
🟨 Propanil										0.08
🟦 Carbofuran				1.2						3.2

Fig. 8. Presence of pesticides

3.2.4. Bacteriological pollution

The confirmed presence of bacteriological germs at high levels in the well and borehole water samples analyzed indicates contamination of faecal origin. Most samples (80 %) were contaminated with microbiological germs. The presence of these germs is most marked by CT total coliforms (28 to 800 UFC/100 mL), fecal coliforms (CF)-Echérichia coli (E. coli) with values varying between 1 and 108 UFC/100 mL and fecal streptococci (SF) with levels of 2 to 9 UFC/100 mL. With the exception of P10-1, wells and boreholes (P1-2, P1-3, P8-1, F5-2, F8-1) located in market-garden areas are heavily contaminated with CT and CF (E.Coli). The presence of these germs in well and borehole water can be explained by the use of organic manure in the fields and by livestock rearing practices in the vicinity of certain sampling points. In fact, P8-1, which contains all the germs tested, and F8-1 are located in an area where the above-mentioned activities are widely practiced. Thus, livestock farming and the use of organic manure have had a negative impact on the microbiological quality of some of the targeted wells and boreholes. The other wells and boreholes (P6-1, F3-1, F6-1) also showing bacteriological contamination are located in or near dwellings (F3-1). The presence of faecal germs in these sources could be linked to domestic discharges, septic tanks, infiltration of surface water (P6-1) (Dimane, et al., 2017), latrines/WCs used in homes located near certain wells and boreholes. In view of the microbiological pollution observed, consumption of water from the wells and boreholes concerned presents significant health risks.

4. CONCLUSION

Pollution in well and borehole water is both anthropogenic and linked to the hydrolysis of silicate rocks. The use of chemical inputs by market gardeners has a negative impact on well and borehole water quality in the town of Koudougou, with the presence of pesticide residues in some waters. All well water samples contained micro-organisms, making them unfit for human consumption without prior treatment.

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