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Contamination of Well Water by Agricultural Inputs in the Irrigated Area of "Office du Niger Niono".

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Abstract: *Agriculture is one of the key sectors of development and an activity that is easy for people to implement. The financial benefits are almost always certain, because both cereal and vegetable productions are part of the daily diet of the populations. Intensive agriculture is accompanied by increased use of agricultural inputs.*

The general aim of this study is the assessment of the quality of the well water of the Office of Niger.

In this work 12 samples of well water, close to the rice growing plots, and 16 soil samples of the plots were taken. Sampling was done during the season (June to September), the off-season (January to April) and the "dead" period (November). The analyses focused on the physico-chemical parameters of the waters, the particle size and the chemical parameters of the soils.

Particle size analysis reveals that soils in the area have a textural class ranging from sandy-loamy to clay soil. According to the FAO textural triangle, these soils are 44% limono-clay and limono-clay-sandy; 38% clay-sandy; 13% clayey and 5% sandy-loamy.

Analyses have shown that the wells have organic BOD_5 pollution above the drinkability guideline (30 mg/L oxygen).

Well water contains high amounts of iron elements up to 3.42 mg/L. The values obtained are higher than the acceptable levels. The content of heavy metals such as lead, varies from 0.8 mg / L to 3.1 mg / L cadmium from 0.07 to 0.15mg / L; levels all higher than the guidelines accepted by the WHO for drinking water.

Chromium is almost present in all wells up to 0.52 mg/L in the prefecture.

Sulphates and nitrates are present in all the wells sampled and often at very high levels: 22.3mg/L of NO_3^- in well 10 and 12.6mg/L of $SO4^{2-}$ in well N°6.

The granulometry results show that with irrigation, these plots can lend themselves to a process of drainage and infiltration of agricultural inputs brought to other sources.

The physico-chemical parameters analyzed may change depending on the period of year.

Keywords: *Contamination, agricultural inputs, well water, Office du Niger*

1. Introduction

Mali is an agro-pastoral country, agriculture is the main income-generating activity; in this regard, the Office du Niger ranks first.

The Office du Niger in Mali manages an irrigated area located on the left bank of the Niger River, about 30 km downstream from Ségou, 250 km downstream from Bamako. The irrigated perimeters there now represent approximately 100,000 ha, installed in the dead delta of the river, the main productions being rice, market gardening, sugar and livestock products (references).

Today the population concerned represents about 500,000 people, about 25,000 family farms are installed in the area, with an average surface area of less than 4 ha per farmer. Rice yields were multiplied by 4 to reach approximately 6 t/ha according to statistics from the Office du Niger. Rice production has increased from 60,000 to more than 500,000 t/year (L'Office du Niger au Mali: amenagements, development and desires 2002).

In Mali, the addition of fertilizer to the soil, whether done in a traditional way (humus amendment) or modern way (chemical fertilizer), is generally not preceded by prior studies on the properties of the soils used. (Doumbia, 1997) despite the existence of specialized structures in this area. However, previous studies have established that the soils of Mali are naturally poor (Piéri, 1989; Onkend and Wend, 1989). Without fertilizing these soils, only15% of the available water is used by plants; with good fertilization, the plants would succeed in recovering almost 50% of this water for their growth (Breman et al, 1998). However, the uncontrolled use of these agricultural inputs can lead to pollution of our environment. In this context, agricultural production to be sustainable must develop approaches aimed at better use of available resources, in particular restoring and maintaining soil fertility, which is one of the most limiting factors in agricultural production (Stroosnijder, 1981; Onken and Wendt, 1989; Payne et al, 1991; Takow et al, 1991; Doumbia et al, 1993 and 1998).

Thus, to improve the yield of their crops, apart from organic manure (which can also be a source of pollution), farmers resort to mineral fertilization, the use of pesticides and fungicides. The difficulty of mineral fertilization for farmers is to determine the right dose to apply to obtain optimal yield. The incorrect application of pesticides and fungicides or their prolonged use has a negative impact on the environment and on product quality. These agricultural practices also lead to degradation and pollution of soil, surface water through runoff, and groundwater through infiltration and leaching (US Environmental Protection Agency, 1977; Cohen et al., 1984; Leistra and Boesten, 1989 , Schiavon et al., 1995), causing great concern, drinking water being in many cases drawn from groundwater. Nitrates, nitrites, sulphates, phosphates, pesticides and metals from mineral and organic applications pollute surface water and groundwater, thus degrading water quality and endangering the health of the population. local population. It is generally agreed that the environmental impact of a pesticide depends on the degree of exposure (resulting from its dispersion and concentration in the environment) and its toxicological characteristics (Severn and Ballard, 1990; Emans et al., 1992).

The uptake of pesticides from the soil by plants is probably one of the major pathways that

lead to their accumulation along the trophic chains and, therefore, to their coming into contact with humans and animals (Paterson et al., 1990).

Fertilizers and heavy metals

The phosphate rock used as a raw material in the manufacture of phosphate fertilizers, depending on its origin, contains high concentrations of heavy metals (Brigden et al., 2002). These heavy metals are partly transferred to phosphate fertilizers and to the by-products formed such as calcium sulphate dihydrate known as phosphogypsum (Rutherford et al. 1994). Only 15% of phosphogypsum waste is recycled and 85% is discharged into the environment (IFA, 1998).

The risk associated with metallic trace elements contained in phosphogypsum and phosphate fertilizers applied to the soil depends on their mobility, in other words their passage in solution to be transferred to plants or polluted in deep groundwater. This mobility is not stable over time depending on several physico-chemical parameters such as pH, redox potential, organic matter content (Kabata-Pendias, 2004). Among the metals treated in common in several studies and contained in phosphate rock, phosphate fertilizers and phosphogypsum there are lead, chromium, copper, zinc, cadmium, uranium, strontium (Kassir LN, 2012).

This study aims to study the impact of the main pollutants, such as nitrates, nitrites, phosphates, sulphates, pesticides and heavy metals from agricultural inputs, in groundwater in the Niono area.

2. Presentation of the Study Area

The Niono zone is limited to the north by that of N'Débougou, to the south by the M'Béwani zone, to the east by the dry zone and to the west by the Fala de Molodo along which s elong the lockers fitted out from the South to the North. It is the oldest production area after Macina. The area includes 4 compartments fitted out for a total area of 14,898 ha. The area has a staff of (83 people); 28 Village Associations (AV); 2 Village Tones (TV); 25 cooperatives; 50 Economic Interest Groups (GIE); 34 Economic Interest Groups and High Labor Intensities (GIE HIMO); 65 Women's Economic Interest Groups (GIEF); and 335 Tertiary Network Servicing Organizations (OERTs).

The area is divided into four compartments: The Retail compartment: 6,652 ha. It is supplied by the 13 km long Retail distributor and directly connected to the Fala de Molodo. This distributor is subdivided into reaches by Fixed threshold regulators. The diverters are equipped with flat valves. As for sprinklers, there are semi-module structures as well as Mask Modules.

- The Grüber compartment: 2,521 ha The Grüber compartment was rehabilitated with that of Kouia in 1990 for an area of 6,130 ha by the ARPON project. The locker is supplied by the 14.7 km long Grüber distributor which takes it directly from the Fala.
- The Kouia locker: 1,284 ha As indicated above, the Kouia locker was rehabilitated in 1990 by the ARPON project. It is served by the 7 km long Kouia distributor which is also directly connected to the Fala. In this compartment, the dividers are equipped with flat valves and the sprinklers with semi-module valves.
- The Kolodougou locker: 3,241 ha It was also rehabilitated in 1990 by ARPON. The Kolodougou locker is supplied by the 7 km long Kouia distributor. As in the Kouia locker, the structures consist of flat valves on the diverters and semi-module valves on the sprinklers.
- The Retail IV rack: 1,200 ha It is supplied by the 16 km long Retail IV distributor. The rehabilitation of Retail IV took place in the 1990s by the Retail project. In this locker the distributor and the dividers are equipped with flat valves and the sprinklers with semi-module valves.

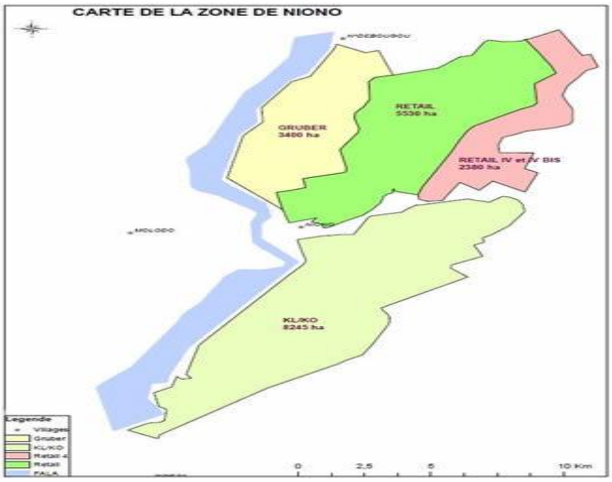

Figure1. *Map of the study area (Niono)*

3. MATERIALS AND METHODOLOGY

Water samples were taken from sprinklers, plots, weirs and adjacent wells in the village of Sériwala. The samples were made according to the diagram below:

The soil samples were identified as follows:

PXSY: where P, S indicate the parcel and the soil, X and Y respectively the numbers specifying the sampling points for the chosen parcel.

S1 = Control soil before the plot; S2 = soil at the start of the plot; S3 = fine soil of the plot; S4 = control soil after the plot

Water samples are identified as follows:

- E1 water from the sprinkler at the entrance to each plot;
- E2 water at the start of the plot;
- E3 water at the end of the plot;
- E4 water from the spillway

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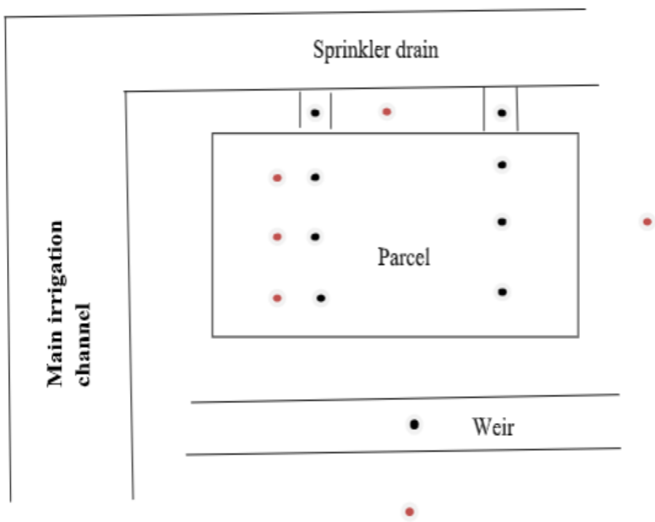

Figure2. *Sampling scheme*

Analyzes focused on the physico-chemical parameters, the evolution of which will be monitored during the sampling periods.

The physico-chemical parameters concerned: pH, temperature, turbidity, color, COD, BOD_5, nitrites, nitrates, phosphates, sulphates, ammoniums, dissolved oxygen, settleable matter, conductivity, TDS, pesticides and some heavy metals (Pb, Cd, Cu, Fe, Co, Cr, Zn), CEC, particle size, structure, organic matter (OM).

To carry out these analyzes we used the multi-parameter field spectrophotometer, the COD reactor, the UV/Visible Spectrophotometer Perkin Elmer Lambda 40, the Atomic Absorption Spectrophotometer (AAS) Perkin Elmer Analyst 200, the Gas Chromatograph (GC) Perkin Elmer Clarus 500 and the Agilent Gas Chromatograph coupled to Mass Spectro (GC-MS).

4. Results and Discussion

Tables 1, 2 and 3 below represent the results of analyzes of water from wells and boreholes adjacent to the rice-growing plots of the village of Sériwala and Niono chosen as the study area.

Table1. *Physicochemical parameters of well water adjacent to the rice plots of Sériwala and Niono*

Sampling Points	Parameters in mg/L				
	DBO_5	PO_4^{3-}	NO_3^-	NH_4^+	SO_4^{2-}
Niono Prefecture		2,0937		.	1,8537
Niono PGD 1	80	.	0,5005	0,0052	0,0517
Niono drilling 2	70	.	0,7889	.	0,0812
Well 1	126	.	0,1183	0,0057	1,2994
Well 2	124	.	.	0,0171	4,6357
Well 3	100	.	0,0075	0,013	3,1794
Well 4	100	.	0,0727	0,0114	2,2837
Well 5	100	.	0,9042	0,0166	4,5514
Well 6	100	0,6707	0,1595	0,0314	12,594
Well 7	110	.	.	0,0414	19,3
Well 8	90	.	0,8559	0,0051	1,6029
Well 9	80	.	3,1347	.	0,4395

Well 10	30	.	22,2616	0,0038	1,6872
Well 11	80	.	2,5645	0,001	2,2499
Well 12	80	.	0,0691	0,0317	11,072

Table2. *In situ parameters of well water adjacent to the rice plots of Sériwala, Niono*

Sampling Points	**Parameters**			
	Conductivity (µS/cm)	**TDS (mg/L)**	**pH eau**	**T°C**
Niono Prefecture	-	-	-	-
Niono PGD 1	69	49	6,1	29,8
Niono drilling 2	42	29	5,6	30,2
Well 1	56	39	6,8	22,1
Well 2	60	42	6,1	23,0
Well 3	56	39	5,9	28,0
Well 4	60	42	6,0	28,9
Well 5	44	31	6	27,8
Well 6	57	40	6,4	25,7
Well 7	56	39	6,4	28,2
Well 8	49	34	6	28,8
Well 9	269	188	6,9	27,5
Well 10	425	297	7,2	28,2
Well 11	97	68	6,6	28,9
Well 12	59	41	6,0	30,0

The Sériwala wells are adjacent to the sampled plots. They are divided between the three selected parts and the center of the village.

- All the wells have organic pollution in BOD_5 above the potability directive (30 mg/L of oxygen). This is explained by the fact that the channel for the evacuation of polluted and loaded irrigation water runs along the entire village in length and width. It constitutes the vector of pollution by infiltration and even by runoff in the event of overflow during the flood period.

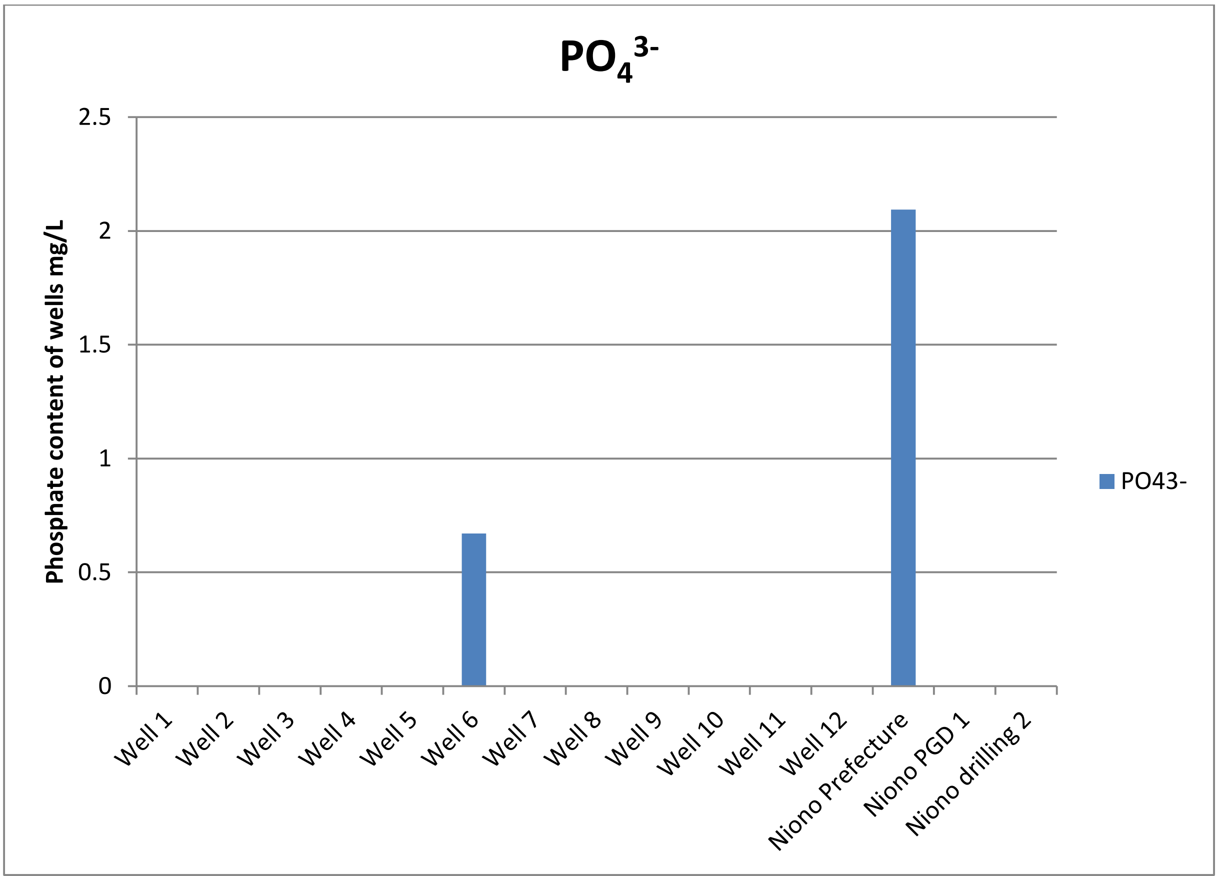

Chart 1

Phosphate, an essential constituent of the DAP (granulated super phosphate) used, is practically absent in all the wells. This is explained by the fact that this element is not at all mobile in the ground, on the contrary it is fixed as soon as it is brought.

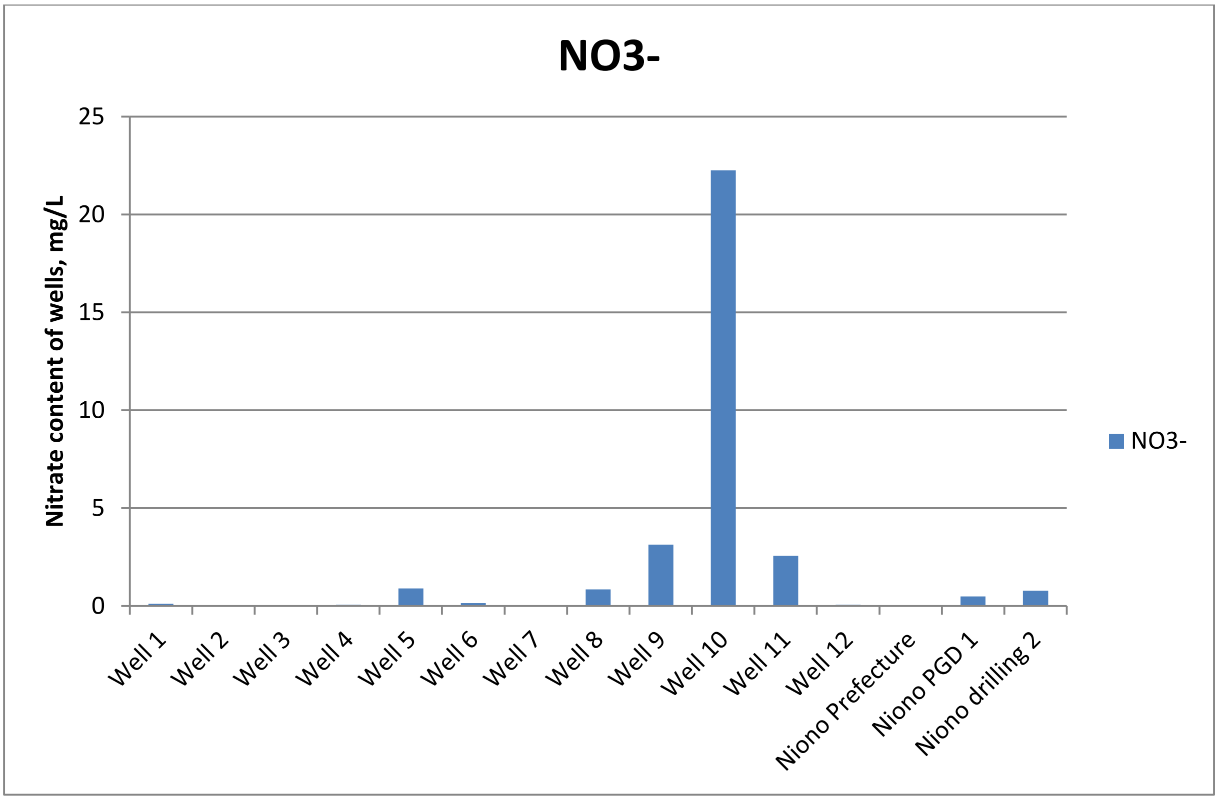

Chart 2

- Nitrates in Sériwala are between 0.0075 mg/L (well 3) and 22.26 mg/L (well 10). This high content is due to the fact that they are easily leachable. Once brought to the soil They are retained by no other process except biological fixation.

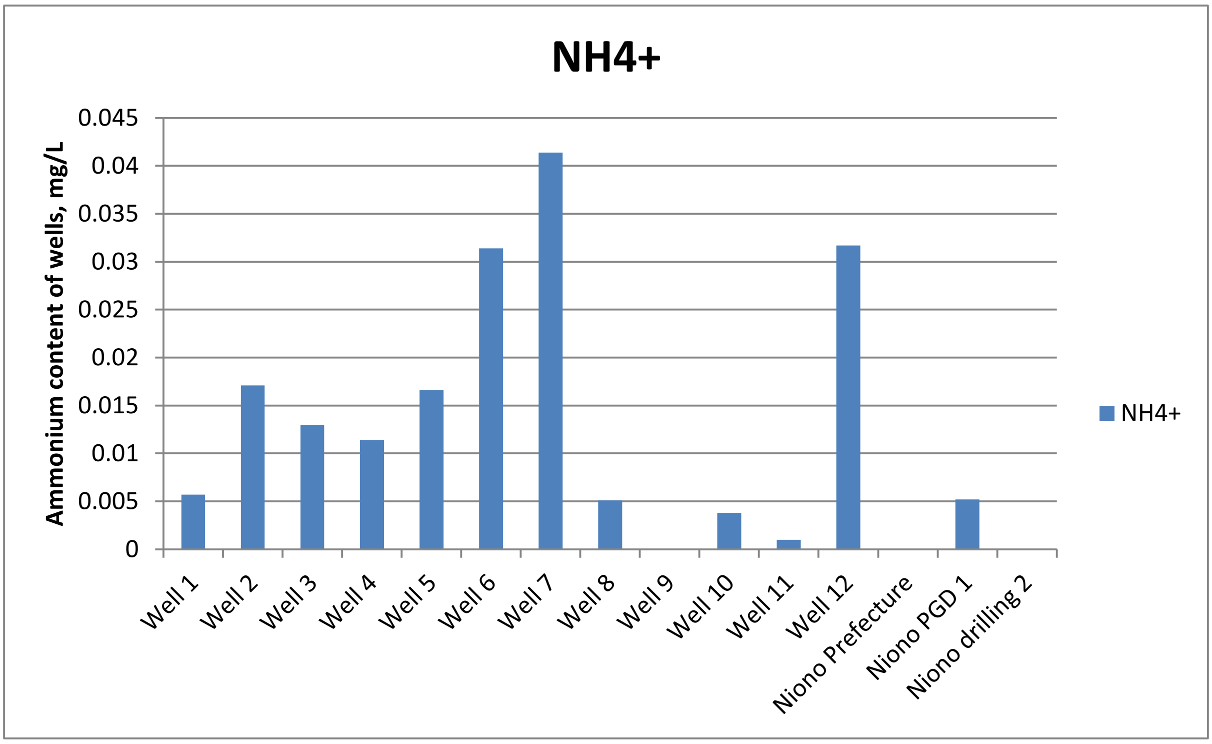

Chart 3

- Ammonium ions are present at Sériwala at concentrations varying between 0.001 mg/L (well 11) and 0.0317 mg/L (well 12). These values are acceptable to the WHO, whose references are 0.5 mg/L.

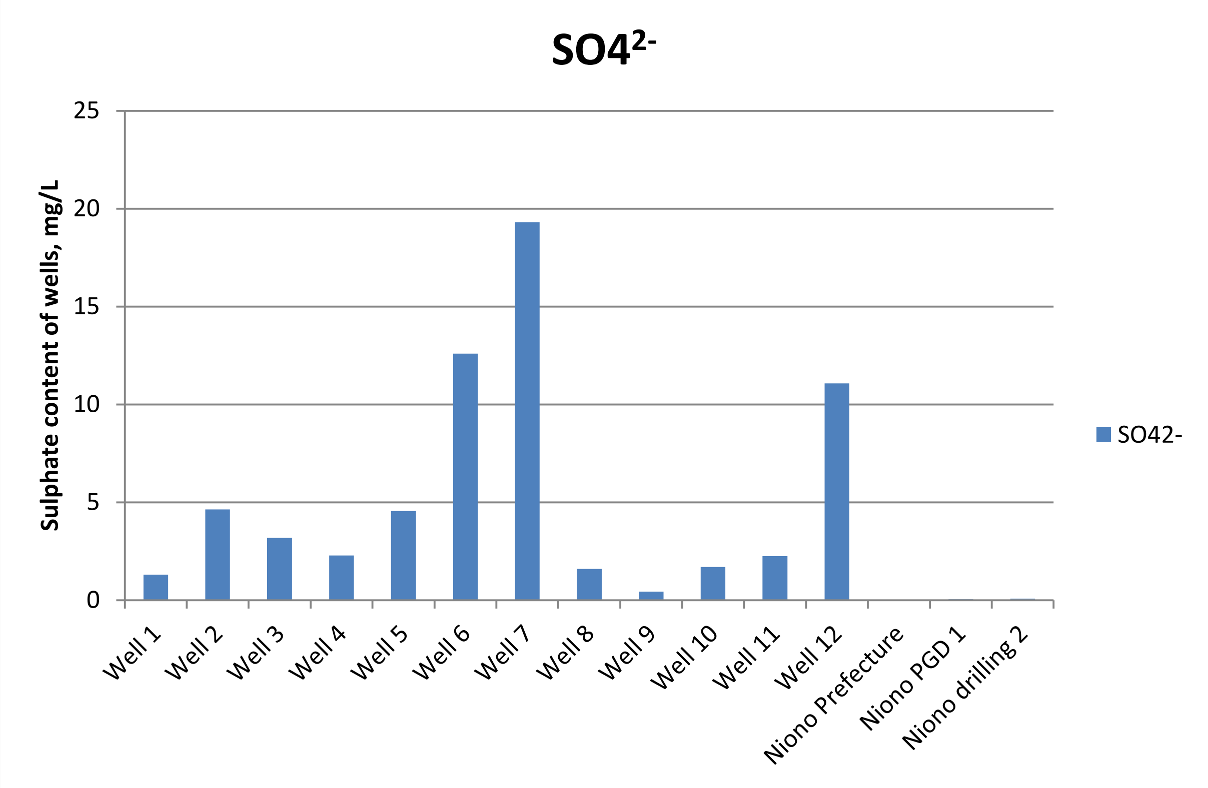

Chart 4

- Sulfates are present in all the wells, however they remain within the rate range accepted by the WHO (250 mg/L)

Levels between 19.3 mg/L (well 7) and 0.052 mg/L (large diameter well 1 Niono) and at Seriwala.

- All the wells with the exception of well 10 (pH=7.2) are acidic with pHs between 5.6 (Niono 2 borehole) and 7.2.

- Temperatures are around 30°C in March 2013. We see higher temperatures in the village of SERIWALA, the town of NIONO.

The well waters were analyzed in situ for conductivities between 42 µS/cm at the Niono 2 borehole and 425 µS/cm at Sériwala well 10.

The TDS also evolve in the same way as the conductivities. If the conductivity is high, the TDS is high and when it is low the TDS will be low.

Table3. *Metal analysis results*

Well	**Elements analyzed in mg/L**						
Adjacent wells/plots	**Pb**	**Cd**	**Cr**	**Cu**	**Fe**	**Co**	**Zn**
Niono Prefecture	0,774	.	0,516	.	.	.	.
Niono PGD 1	1,118	0,088	0,155	.	.	.	.
Niono drilling 2	1,876	0,05	0,166	.	.	.	.
Well 1	1,409	.	.	.	0,278	.	.
Well 2	3,091	0,059	0,048	0,052	1,324	0,009	.
Well 3	1,235	0,15	.	0,026	3,326	0,2	.
Well 4	2,558	0,137	0,054	0,056	1,228	0,097	.
Well 5	1,372	0,049	0,148	.	1,902	0,15	.
Well 6	2,232	0,091	0,053	.	2,947	.	.
Well 7	2,029	0,076	0,151	.	3,417	.	.

Well 8	0,796	0,066	0,157	.	1,713	0,905	.
Well 9	1,548	0,077	0,304	.	.	.	.
Well 10	1,999	.	0,203	.	0,336	.	.
Well 11	1,999	0,11	0,227	.	.	.	.
Well 12	1,736	0,103	0,238	.	2,017	.	.

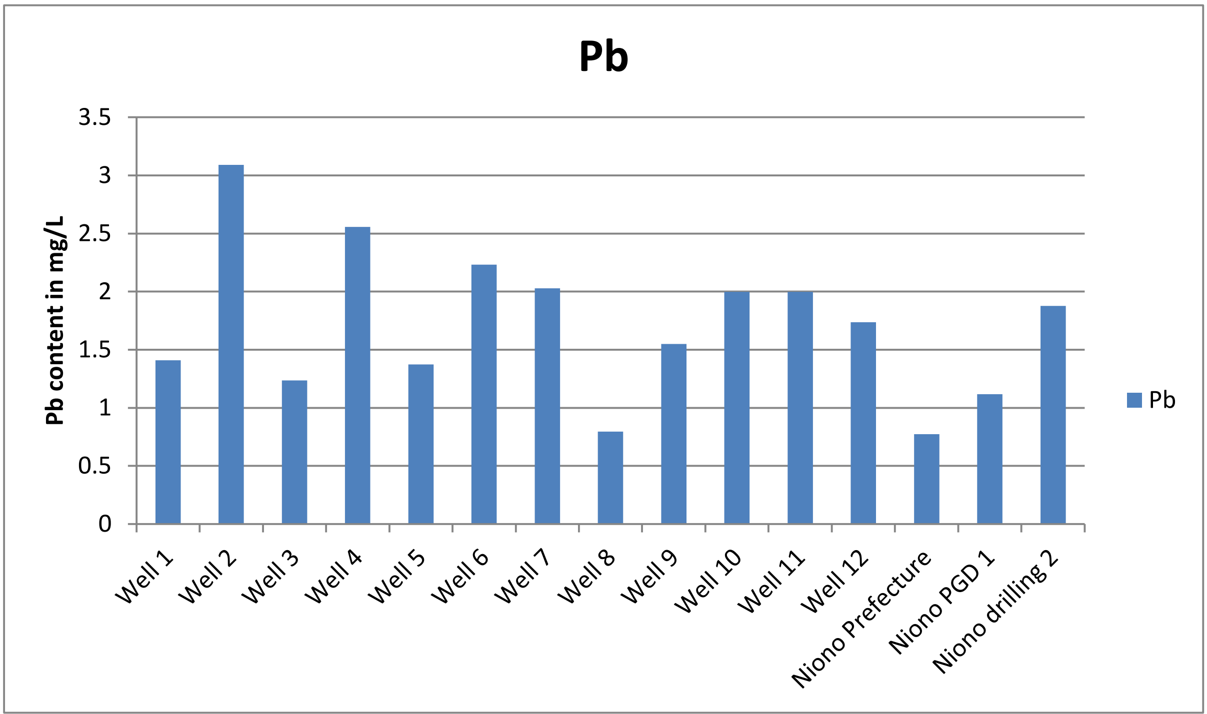

Chart 5

- In Sériwala, wells 1 to 12, we note the presence of lead and also in the Niono drilling 2 and Niono PGD 1. The contents are between 0.796 mg/L (well 8) and 3.091 mg/L (well 2). Values all above the WHO guidelines for the quality of water for human consumption (0.05 mg/L).

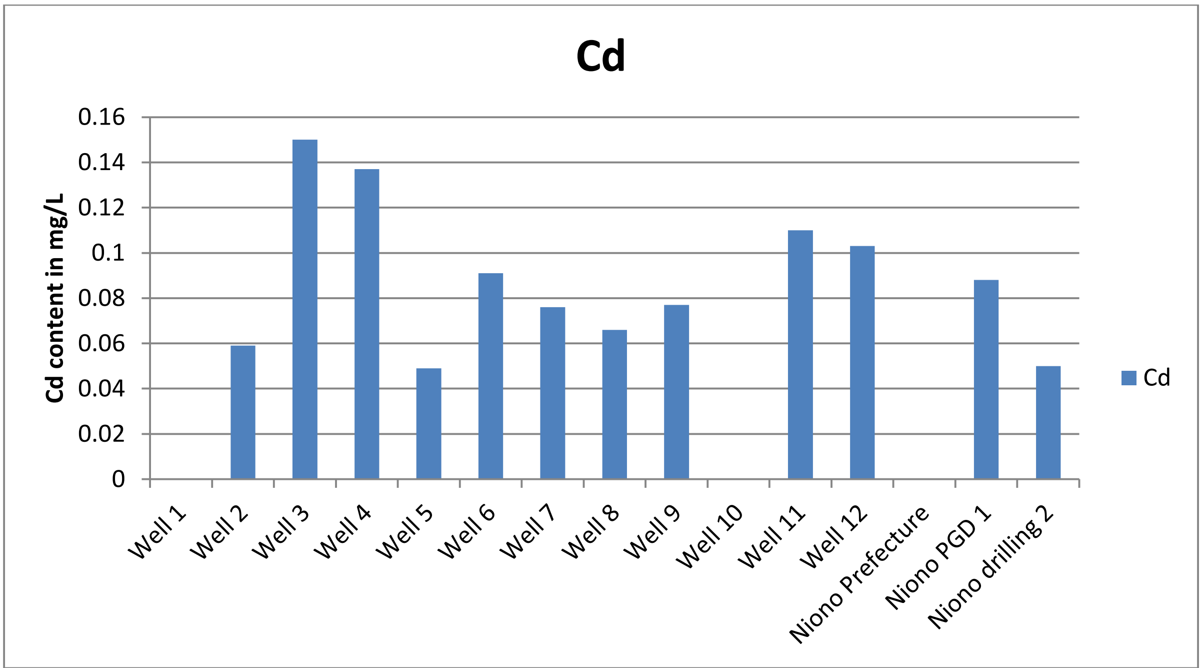

Chart 6

- Cadmium has a content of between: 0.049 mg/L (well 5) and 0.15 mg/L (well 3) at Sériwala and Niono. Like lead, these levels are higher than the standard accepted by the WHO for drinking water, which is 0.005 mg/L.

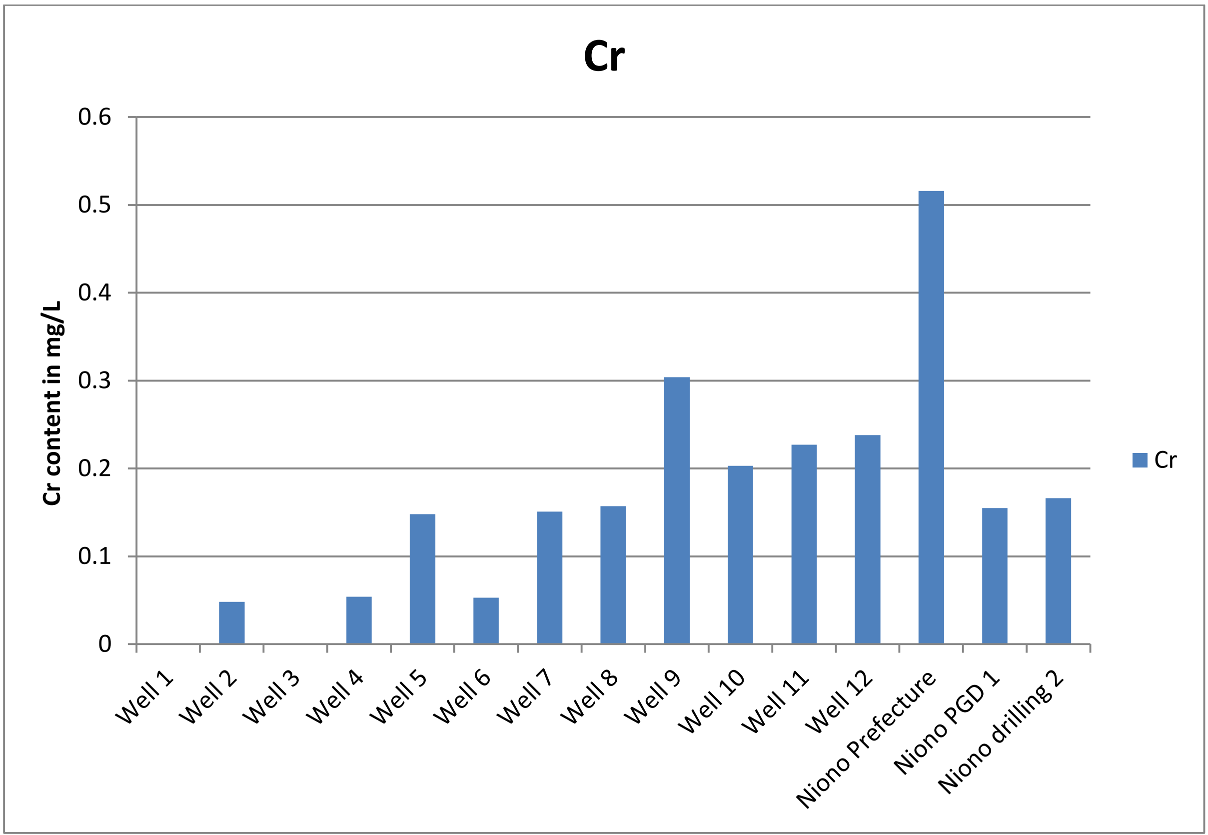

Chart 7

- Except wells 1 and 3, there is chromium in the others; 0.52 mg/L is reached at the Niono Prefecture. In most cases, the concentrations exceed the WHO guideline values (0.05 mg/L).

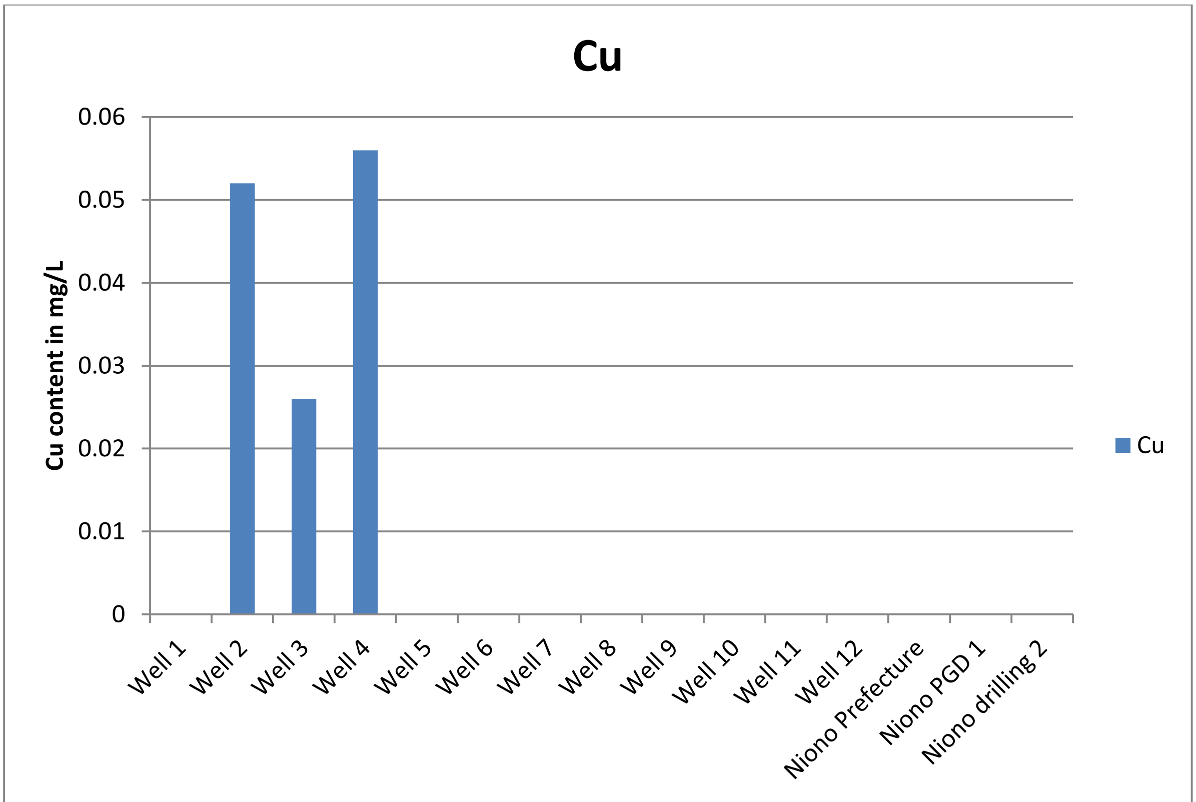

Chart 8

- Only wells 2, 3 and 4 contain small amounts of Cu between 0.026 mg/L (well 2) and 0.056 mg/L (well 3); levels allowed according to WHO guidelines (1 mg/L).

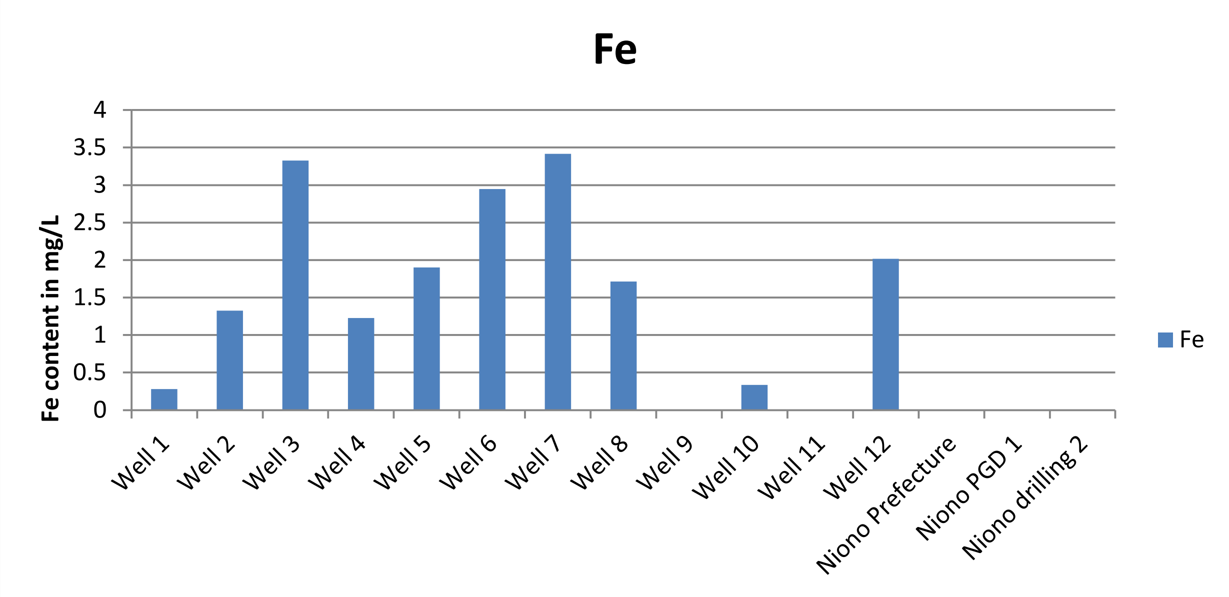

Chart 9

- These well waters contain high quantities of iron elements, reaching a concentration of 3.417 mg/L at the level of well 7. The values obtained are higher than the acceptable levels of 0.2 mg/L.

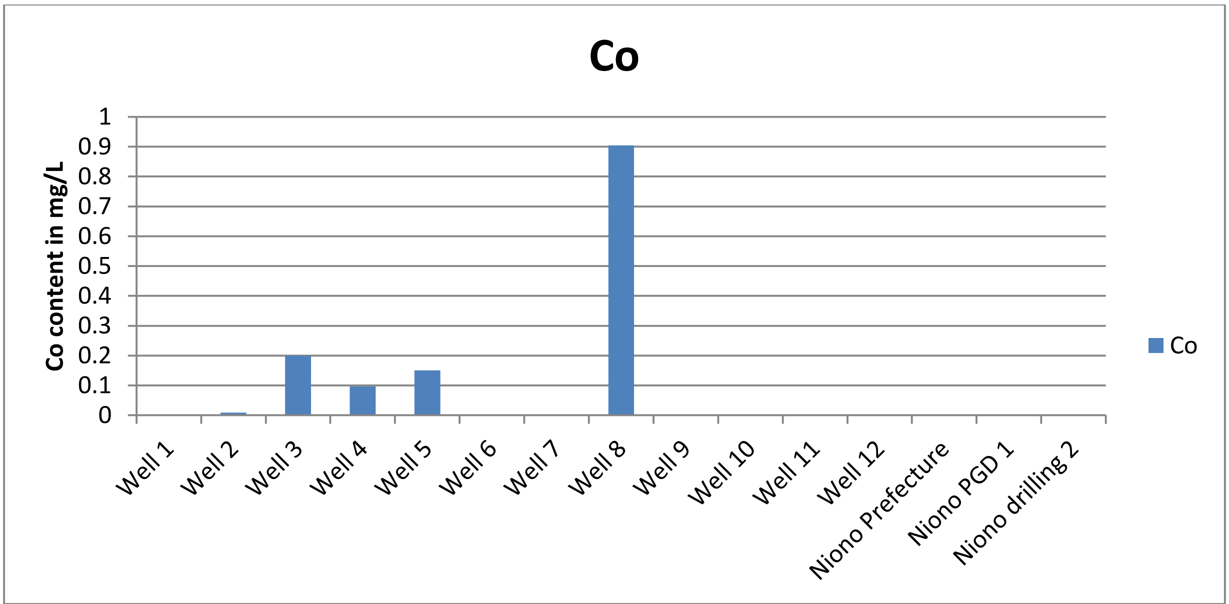

Chart 10

- The trace element Co contents reach 0.905 mg/L in well 8. It is almost absent in the well waters analyzed at Sériwala and Niono.

- Zinc is absent in all the water from wells and boreholes analyzed in the area.

In the study area, mineral fertilizers containing trace elements are rarely applied, hence their absence in the wells. However, there may be some traces in the organic manures applied. The case of well 8 could only be explained by intrusion or internal pollution, the well being located near a barn

Table4. *Particle size analysis of soils*

Sampling points	Sand, %	Silt, %	Clay, %
P1S1	88	0	11
P1S2	55	6	39
P1S3	55	20	25
P1S4	59	3	37
P2S1	67	1	32

P2E2	63	5	32
P2S3	68	4	28
P2S4	57	8	35
P3S1	55	4	41
P3S2	39	27	34
P3S3	55	20	24
P3S4	48	14	38
P4S1	36	21	43
P4S2	37	26	37
P4S3	49	16	35
P4S4	35	21	43

Particle size analysis shows a textural class ranging from sandy loam to clay soil. According to the textural triangle of the FAO, these soils are 44% silty-clayey and silty-clayey-sandy; 38% clay-sandy; 13% clayey and 5% sandy-loamy.

The plots are mainly silty-clayey and silty-clayey-sandy. The control soils located before or after the plots are clayey or clayey-sandy; these are soils from the road or from the dikes of the irrigation canals, which explains their clayey state. The results show that with irrigation, these plots can lend themselves to a process of drainage or infiltration of agricultural inputs brought to wells and boreholes.

5. Conclusion

In situ parameters were determined for all well, borehole and plot water samples. These are the temperature, the pH, the conductivity, the level of dissolved salts.

The analysis of the physical and physicochemical parameters was carried out in the Laboratories of Analytical Chemistry (LCA), Sciences and Techniques of the Environment (LSTE).

- All the wells, except number 10, have organic pollution in BOD_5 above the potability directive (30 mg/L of oxygen). Well 10 is the least altered with a content of 30 mg/L.
- The content of heavy metals such as lead varies from 0.8 mg/L to 3.1 mg/L; cadmium from 0.07 to 0.15mg/L. These parameters may change depending on the time of year.
- Well water contains high amounts of iron elements. The latter is found in the samples analyzed reaching in well 7 a concentration of 3.42 mg/L. The values obtained are above the acceptable levels.
- Chromium is almost present in all wells up to 0.52 mg/L in the prefecture. These parameters may change depending on the time of year.
- Phosphate, an essential constituent of the DAP (granulated super phosphate) used, is practically absent in all the wells.
- Sulphates and nitrates are present in all the wells sampled and often at very high levels: 22.3 mg/L of NO3- in well 10 and 12.6 mg/L of SO42- in well 6.
- Particle size analysis shows a textural class ranging from sandy loam to clay soil. According to the textural triangle of the FAO, these soils are 44% silty-clayey and silty-clayey-sandy; 38% clay-sandy; 13% clayey and 5% sandy-loamy.

The results show that with irrigation or even during periods of flooding, these plots can lend themselves to a process of drainage or infiltration of agricultural inputs brought to other sources, in particular wells and boreholes adjacent to the plots. It should be noted that these studied parameters may vary according to the seasons.

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