

Research Article

CHARACTERIZATION AND QUALITATIVE AND QUANTITATIVE ANALYSIS OF SOIL SAMPLES BY THE ANALYTICAL METHOD OF X-RAY FLUORESCENCE SPECTROMETRY: CASE OF THE AGRICULTURAL SITE OF NIAKHENE-SENEGAL

^{1,2*} Djicknack DIONE, ^{1,2} Papa Macoumba FAYE, ^{1,2} Oumar NDIAYE, ^{1,2} Nogaye NDIAYE, ¹ Mamadou FAYE, ^{1,2} Alassane TRAORE, ^{1,2} Ababacar Sadikhe NDAO

¹Institute Technologies of Nuclear Applied, Cheikh Anta Diop University of Dakar, Senegal.

²Department of physics of Faculty of sciences and Techniques, Cheikh Anta Diop of Dakar, Senegal.

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ABSTRACT

As part of the study of soil fertility, the concentrations of iron, calcium, manganese, and potassium were measured using X-ray fluorescence technique at both the agricultural site and the reference site. The abundances of these elements were calculated for depths of 0-20 cm and 20-40 cm by determining the differences between the contents of the agricultural site and the reference site. Using ArcGIS 10.3 software, the spatial distribution of the calculated differences in mineral elements was mapped. For depths of 0-20 cm and 20-40 cm, variations in iron, calcium, potassium, and manganese were frequently observed across the entire surface of the agricultural site. Notably, there were significant losses of iron, potassium, and manganese at specific points on the surface (0-20 cm), amounting to 403.54 ppm, 81.44 ppm, 176 ppm, 383 ppm, 323 ppm, 103 ppm, and 132 ppm, respectively. Similarly, at the depth of 20-40 cm, losses were observed, with values of 265.77 ppm, 11.26 ppm, 52.55 ppm, 129.11 ppm, 4.55 ppm, 103.88 ppm, 156.28 ppm, 357.03 ppm, and 4.55 ppm at certain locations on the site.

Keywords: X-ray fluorescence, soil samples, fertility, soil loss, fertilizer amendment.

INTRODUCTION

In sub-Saharan African countries, soils exhibit a low level of inherent fertility [1], which is associated with specific natural constraints in each agro-ecological zone. These deficiencies are crucial factors affecting production. While many plants are known to thrive and yield in poor soils, achieving optimal growth requires minimal soil nutrient richness [2,3]. Some authors advocate addressing soil nutrient deficiencies through the use of specific fertilizer formulations [4,5]. However, the majority of growers are unaware of these formulations and do not employ any other nutrient enhancement technology for fruit and vegetable production. Moreover, the utilization of various fertilizer types necessitates accurate soil analysis, increasing the production costs for farmers. Numerous studies have already been conducted on soil fertilization in Africa [6,7]. Nevertheless, substantial heterogeneity exists between countries concerning soil physical and chemical properties, crop history, and farm management.

In light of global warming and the heightened demand for expertise in the agro ecological field, the study of the resilience of agricultural systems becomes paramount. Thus, a soil characterization campaign was conducted on the rural campus of Niakhene to contribute to evaluating fertility and erosion. The application of nuclear techniques in agriculture involves mass spectrometry (utilizing stable isotopes), gamma spectrometry (utilizing unstable isotopes emitting gamma rays), X-ray fluorescence spectrometry (determining essential, non-essential elements, microfilaments, and heavy metals), and other advanced quantification methods, such as inductively coupled plasma mass spectrometry (ICP-MS) and atomic absorption spectrometry (AAS).

For the selected Niakhène agricultural site, which had been previously plowed before sampling, X-ray fluorescence technique was employed to determine the Iron, Manganese, Calcium, and Potassium contents-essential elements for plant growth within certain thresholds.

MATERIALS AND METHODS

Description of the study and reference site

The study site is located in Niakhene which is in the region of This department of Tivaouane. The distance between Dakar and the study site is 184 km. The nature of the soil in the agricultural site is sandy and light. The advantage is that this type of soil was very permeable to water and air and is easy to work. It flows naturally due to its porous texture. However, with its very filtering nature, it retains little water and few nutrients. Devoid of organic matter, it is easily washed away by watering or rain. The surface of the agricultural site is 11 hectares and is limited by five UTM coordinates. The mapping of the study site and the sampling techniques are shown in Figure 1.



Figure 1: Sampling samples in the study sites

*Corresponding Author: Djicknack DIONE,

¹Institute Technologies of Nuclear Applied, Cheikh Anta Diop University of Dakar, Senegal, ²Department of physics of Faculty of sciences and Techniques, Cheikh Anta Diop of Dakar, Senegal.

The reference site is located in Niakhene 7 km from the agricultural site. The GPS coordinates of the site are 14°42'52.45"N and 17°14'47.50"W. The reference site is located in the environment of the agricultural field studied. Figure 1 gives the state of our reference site.

Sampling method in the study and reference site

The soil of the study site has already been plowed on its surface with humus disturbance up to 15 cm deep. This is why we collected 02 profiles of 0-20 cm and 20-40 cm for each sampling point with a gap of 50 m between the sampling points. For the cultivated site. 47 sampling points were taken from 7 transects. Each sampling point of the cultivated site, the depth of the core was subdivided into two sub-samples of 0-20 cm and 20-40 cm. We had taken 94 sub-samples from the cultivated site. In the Fig 1 shows the detailed sampling plan with the different points sampled.

For the reference site, which is 7 km from the cultivated site, three reference sampling points were chosen (Ref. 1. Ref. 2 and Ref. 3). For Ref. 1, we had chosen a depth of 75 cm. inside the soil we collected 15 sub-samples. For Ref. 2 we obtained 19 subsamples and also in Ref. 3. Finally, we took 53 samples. The samples are then placed in plastic bags and transported to the laboratory. Arrived at the laboratory, the samples must be dried, remove the roots then crushed, sieved before being analyzed.

Analysis of samples by X-ray fluorescence

Experimental method

Soil samples are directly presented to the X-ray fluorescence analyzer with a silver Ag anode as excitation source and an optimized large-geometry detector with multiple filters as secondary sources. Figure 2 is a good illustration of the Niton XLT900s X-ray tube with the arrangement of the filters.

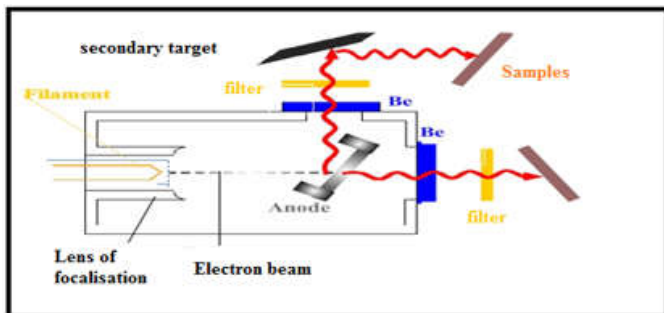


Figure 2 : X-ray tube with typical excitation geometry

In table 1 we present the specifications and operating conditions of the Niton XLT900s spectrometer with different types of filters.

Table 1: Niton XLT900s Spectrometer specification and operating conditions.

Resolution	178 eV@ Mn Ka
Window thickness	12.7 μm Be
Excitation Tube	50KV, 40 A maximum power 2W
Beam diameter	7mm
Filters	List of targeted elements
Excitation Source Ag	Sb, Sn, Cd, Pd, Ag, Mo, Nb, Zr, Sr, Rh, Bi, As, Se, Au, Pb, W, Zn, Cu, Re, Ta, Hf, Ni, Co, Fe, Mn, Cr, V, Ti, Th, U
Sandwich of Al, Ti and Mo	Ba, Sb, Sn, Cd, Pd, Ag
Filter of Cu	Cr, V, Ti, Ca, K
No Filter	Al, P, Si, Cl, S, Mg

Principe

Its principle consists in subjecting a sample to intense X-radiation, which has the effect of ionizing the atoms by ejecting the electrons located on the layers close to the nucleus. The atom then returns to a stable state by reorganizing its electron cloud [8,9]. In particular, the space left by the ejected electron is filled by an electron from a more external layer. This transition is radiative and is therefore accompanied by an emission of an X-ray fluorescence photon of energy equal to the energy difference between the starting and arrival levels of the recombined electron, and which is the signature of the emitting atom. By measuring the fluorescence intensity at each energy, an X-ray emission line spectrum is obtained which depends on the composition of the sample. One can then determine the total content of all elements in the sample with an atomic number greater than a certain value which depends on the excitation energy [10]. This phenomenon is due to the fact that low Z atoms have a low fluorescence yield; it does not concern heavy metals [11].

RESULTS AND DISCUSSIONS

Spatial distribution of mineral elements

The elemental analysis of the various samples taken at Niakhène by the X-ray fluorescence technique made it possible to spatialize the calcium, iron, potassium and manganese contents. Results in ppm of these elements from all samples are summarized in Table 2 for depths of 0 to 20 cm and in Table 3 for depths of 20 to 40 cm.

Table 2: Elements contents in Fe. Mn. K and Ca in 0-20 cm depth profile

SAMPLE	Fe (ppm)	Mn (ppm)	K (ppm)	Ca (ppm)	SAMPLE	Fe (ppm)	Mn (ppm)	K (ppm)	Ca (ppm)
S1	4531.07±63.74	90.18±16.93	3346.42±162.01	596.06±91.62	S106	2615.79±52.71	40.31±15.98	2246.53±70.61	<LOD
S8	4098.62±60.54	49.5±15.48	2483.74±75.02	280.41±43.44	S108	2803.05±54.16	48.56±16.10	2618.46±134.72	<LOD
S10	2263.67±50.59	48.15±16.48	1993.48±184.94	<LOD	S114	2579.06±51.87	67.41±16.77	2782.34±147.32	<LOD
S22	3161.76±59.05	72.15±17.64	2529.79±74.54	<LOD	S116	2993.55±60.28	60.03±17.95	1648.75±62.38	<LOD
S24	3873.33±63.23	74.49±17.46	3715.09±169.26	845.66±97.16	S134	3219±57.99	85.79±17.74	3121.07±155.86	<LOD
S28	4782±71.56	83.04±18.32	4151.04±178.23	923.17±99.83	S136	3242.49±52.79	64.31±15.37	3135.2±156.86	553.49±89.32
S30	2473.23±50.99	50.89±16.19	1966.21±66.96	<LOD	S138	3144.49±57.27	47.65±16.34	2364.65±138.66	<LOD
S50	2844.36±55.55	83.46±17.81	2155.16±69.91	121.99±40.43	S140	3674.57±62.59	55.59±16.92	3491.94±164.04	174.39±82.30
S52	2963.62±55.77	64.05±16.88	1715.61±121.60	<LOD	S142	3107.48±57.12	56.91±16.53	1857.77±125.61	<LOD
S54	3481.52±60.62	56.44±16.91	2938.48±152.18	416.88±86.41	S144	3308.24±58.19	55.34±16.36	2010.24±129.59	634.15±88.63
S60	3357.33±59.50	49.3±16.54	3132.96±157.29	586.46±90.74	S146	2788.33±54.36	59.47±16.66	2099.02±131.93	602.52±88.05
S78	2912.51±55.06	59.89±16.57	1880.94±125.57	<LOD	S148	3743.71±62.48	78.53±17.62	4268.87±179.82	601.72±93.34
S82	2454.81±50.54	48.73±15.95	2017.73±67.13	<LOD	S162	3866.05±63.79	58.58±16.98	2684.46±130.24	<LOD
S84	2204.26±44.62	61.3±15.23	2311.55±71.03	500.72±44.79	S164	3080.97±55.65	53.28±16.17	2879.48±151.43	205.23±80.47
S86	2963.49±56.20	62.41±16.87	2670.78±76.08	185.31±41.74	S168	3287.54±58.74	56.1±16.64	2400.56±140.19	<LOD
S88	2410.59±51.09	53.54±16.55	1895.62±66.16	1742.48±56.80	S170	2182.74±48.11	51.68±16.11	1888.76±125.40	<LOD
S90	2483.9±51.83	51.62±16.57	1364.55±110.85	<LOD	S178	3499.16±61.02	67.49±17.37	2867.01±151.11	461.98±87.06

<LOD : Limit Of Detection

Table 3: Elements contents in Fe. Mn. K and Ca in 20-40 cm depth profile

SAMPLE	Fe (ppm)	Mn (ppm)	K (ppm)	Ca (ppm)	SAMPLE	Fe (ppm)	Mn (ppm)	K (ppm)	Ca (ppm)
S1	4103.12±65.77	73.61±65	2127.74±133.65	<LOD	S106	3634.22±61.94	60.02±17.01	1989.88±129.89	<LOD
S8	4055.26±60.79	66.82±16.30	2363.79±140.17	<LOD	S108	2916.82±55.23	62.04±16.68	1827.42±124.80	<LOD
S10	2082.75±43.85	47.13±14.82	1415.96±112.04	<LOD	S114	2662.71±49.14	49.06±14.91	1474.42±114.86	<LOD
S22	2923.53±55.89	73.87±17.33	1919.77±126.92	<LOD	S116	3553.62±61.10	59±16.91	2367.44±135.05	<LOD
S24	2955.12±55.64	65.13±16.81	1917.08±126.78	<LOD	S134	3753.05±62.26	74.2±17.46	2345.55±73.13	443.7±73.03
S28	3434.14±59.63	49.8±16.33	1983.01±129.38	<LOD	S136	2824.2±50.63	53.84±15.16	1850.31±125.08	<LOD
S30	3135.82±57.22	77.69±17.29	2753.37±147.18	<LOD	S138	3469.63±56.10	87.2±16.67	1878.85±126.62	<LOD
S50	2969.65±55.89	46.12±16.08	1714.04±121.49	<LOD	S140	3259.88±58.33	57.86±16.57	2042.51±130.70	209.53±79.40
S52	3442.19±59.95	60.29±16.77	1859.9±126.82	<LOD	S142	3353.26±59.05	62.79±16.89	2073.41±131.11	<LOD
S54	3451.85±56.12	51.57±15.57	2027.8±130.54	<LOD	S144	3213.34±52.65	51.49±14.87	1899.03±126.89	<LOD
S60	4048.3±66.33	65.52±17.72	2423.34±141.10	<LOD	S146	4286.42±66.94	75.98±17.66	2305.11±138.15	<LOD
S78	3548.04±63.41	57.77±17.76	1827.15±64.81	<LOD	S148	3290.46±57.86	40.52±15.71	1477.63±115.47	<LOD
S82	2571.05±48.49	43.49±14.82	1320.9±109.81	<LOD	S162	4072.93±65.09	58.85±16.91	2446.14±141.78	<LOD
S84	3203.1±56.62	62.47±16.54	1535.69±117.50	<LOD	S164	3522.96±59.63	65.23±16.73	1768±124.92	<LOD
S86	3516.06±60.42	60.99±16.81	2021.63±131.04	368.78±83.24	S168	2798.97±55.99	39.51±16.47	1543.48±117.19	<LOD
S88	2875.53±57.955	89.88±18.73	1452.02±114.95	<LOD	S170	3162.14±57.70	48.09±16.44	1862.2±125.58	<LOD
S90	2771.8±53.93	49.16±16.18	1542.11±116.59	<LOD	S178	3710.4±63.41	74.64±17.71	1749.17±64.81	478.05±44.19

<LOD : Limit Of Detection

Only the elements mentioned above were considered in this study of spatial variability. To illustrate the variations in the concentration of the surface (0-20 cm) and depth (20-40 cm) contents. The results were presented in the form of a spatial distribution using the ArcGis 10.3 software. Potassium (K) is an essential element for all living beings. It is abundant in nature and exists in considerable quantities [12] Potassium stimulates root growth and improves water and nutrient uptake. It promotes cellulose synthesis and reduces the risk of lodging in plants. It is a necessary element for the activation of at least 60 enzymes involved in plant growth [13, 14]. Manganese is used in plants as a major contributor to various biological systems including photosynthesis respiration and nitrogen assimilation[15]. Manganese is also involved in pollen germination pollen tube growth root cell elongation and resistance to root diseases.

The interest of this characterization work falls within the current context of world agriculture because the quality of agri-food products is becoming increasingly important particularly with regard to vegetable production [15]. Metal trace elements have always been a source of soil contamination due to anthropogenic activities [16]. This soil pollution can physiologically affect plants by decreasing their biomass and photosynthetic activity and disrupting nutrient uptake [17,18]. This is why it is interesting to be able to recognize if a cultivated soil is free from contamination or on the contrary if it has kept track of potentially dangerous metal inputs and to clearly distinguish the part of what is natural (useful to the plant) and what is contamination of human origin.

Variability of manganese, Iron, potassium and Calcium content

The Figure3 represents the variation in element concentrations of Manganese, Iron, potassium and Calcium

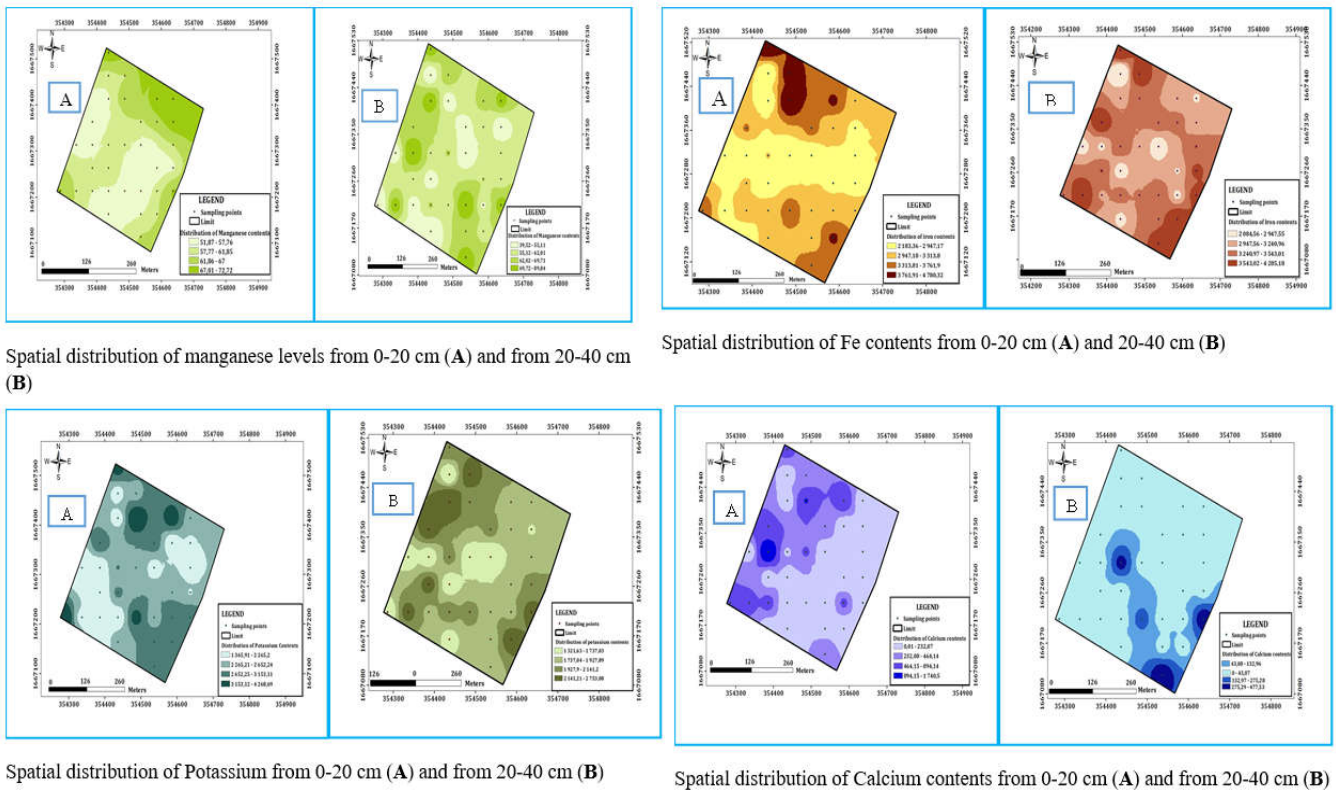


Figure 3 :Spatial distribution of Ca, Mn, Fe and K contents from 0-20 cm (A) and from 20-40 cm (B)

In Figure3, manganese (Mn) concentrations in the 0-20 cm depth range vary from 51.87 to 72.72 ppm and the range is 39.52 to 89.84 in the 20-40 cm range. Despite similarities among soil samples, plant fertilization reduces manganese toxicity by enhancing binding with cell walls, limiting cytoplasmic concentration [19,20]. Manganese, though generally scarce in soils, serves as an essential trace element and exhibits a distinct affinity for Metallic Trace Elements (MTE) [21].

Iron (Fe) content variability in soil samples ranges from 2183.36 to 4780.32 ppm in the 0-20 cm depth range and from 2084.56 to 4285.18 ppm in the 20-40 cm range, as shown in Figure 3. The spatial distribution of Fe contents is illustrated in Figure 3, with the highest value observed at 0-20 cm. Iron, recognized as a trace element for plants, may lead to plant deficiency when lacking due to factors like excess limestone or an imbalance between Fe and Mn. Control measures involve the use of complexing or sequestering products for efficient iron assimilation by plants without excessive fixation in the soil [22,23].

Potassium (K) concentrations in the studied soils, presented in Figure3, vary from 1365.91 to 4268.69 ppm in the 0-20 cm depth range and from 1321.63 to 2758.08 ppm in the 20-40 cm range. The spatial distribution distinguishes the K content, with the highest value obtained at 0-20 cm. It is important to differentiate total potassium from exchangeable potassium, which exhibits considerable variability due to climatic and agricultural soil factors, posing challenges for interpretation by agronomists [24].

Figure3 also displays the spatial distribution of calcium (Ca) contents. Calcium concentrations in soil samples range from 0 to 1740.5 ppm in the 0-20 cm depth range (A) and from 0 to 477.53 ppm in the 20-40 cm depth range (B). The presence of calcium in soil contributes to an increase in total organic matter content and the incorporation of organic matter over a substantial thickness of cultivated land [25]. Calcium's influence leads to the formation of residual humin, providing resistance against microbial action through fine particles of calcium carbonate. Calcium also induces rapid oxidation of lignin, slowing down its fragmentation and mineralization by microorganisms [26,27].

Study of the abundance of elements

After the study of the spatial distributions of the contents in the agricultural site, we made the difference with the data obtained in the reference site. The abundance expressed in ppm for calcium, Potassium, iron and manganese for depths of 0 to 20 cm and for depths of 20 to 40 cm are reported in tables 4 and 5.

Table 4: Abundance of elements in 0-20 cm depth profile

Samples	Abundance of Fe	Abundance of Mn	Abundance of K	Abundance of Ca	Samples	Abundance of Fe	Abundance of Mn	Abundance of K	Abundance of Ca
S60	770	-21	1245.55	505.31	S106	575	-30	642.38	-81.15
S114	-8	-3	894.93	-81.15	S22	656	2	1247.79	472.34
S108	216	-22	731.05	-81.15	S136	407	-6	-238.66	-81.15
S86	377	-8	783.37	104.16	S116	912	-11	979.60	380.83
S30	-114	-20	78.80	-81.15	S178	895	-3	1051.07	335.73
S170	-404	-19	1.35	-81.15	S54	-323	-14	106.07	-81.15
S88	-176	-17	8.21	1661.33	S10	-103	-22	-522.86	-81.15
S84	-383	-9	424.14	419.57	S90	1286	-19	1827.68	764.51
S1	1944	20	1459.01	514.91	S24	632	4	1233.66	-81.15
S140	1088	-15	1604.53	93.24	S134	1279	15	797.05	-81.15
S138	558	-23	477.24	-81.15	S162	-132	-12	130.32	-81.15
S164	494	-17	992.07	124.08	S82	326	-22	-6.47	-81.15
S148	1157	8	2381.46	520.57	S78	201	-11	211.61	521.37
S50	257	13	267.75	40.84	S146	2195	-11	2263.63	842.02
S142	521	-14	-29.64	-81.15	S28	377	12	-171.80	-81.15
S8	1512	-21	596.33	199.26	S52	721	-7	122.83	553.00
S168	701	-15	513.15	-81.15	S144	29	-15	642.38	-81.15

Table 5: Abundance of elements in 20-40 cm depth profile

Samples	Abundance of Fe	Abundance of Mn	Abundance of K	Abundance of Ca	Samples	Abundance of Fe	Abundance of Mn	Abundance of K	Abundance of Ca
S60	1120.22	-1.21	164.39	0	S106	-4.55	73.87	-339.18	0
S114	-265.37	49.06	-784.53	0	S22	-103.88	53.84	-408.64	0
S108	-11.26	62.04	-431.53	0	S136	625.54	59.00	108.49	0
S86	587.98	60.99	-237.32	368.78	S116	782.32	74.64	-509.78	478.05
S30	207.74	77.69	494.42	0	S178	523.77	51.57	-231.15	0
S170	234.06	48.09	-396.75	0	S54	-845.33	47.13	-842.99	0
S88	-52.55	89.88	-806.93	0	S10	-156.28	49.16	-716.84	0
S84	275.02	62.47	-723.26	0	S90	27.04	65.13	-341.87	0
S1	1175.04	73.61	-131.21	0	S24	824.97	74.20	86.60	443.7
S140	331.8	57.86	-216.44	209.53	S134	1144.85	58.85	187.19	0
S138	541.55	87.20	-380.10	0	S162	-357.03	43.49	-938.05	0
S164	594.88	65.23	-490.95	0	S82	619.96	57.77	-431.80	0
S148	362.38	40.52	-781.32	0	S78	1358.34	75.98	46.16	0
S50	41.57	46.12	-544.91	0	S146	506.06	49.80	-275.94	0
S142	425.18	62.79	-185.54	0	S28	514.11	60.29	-399.05	0
S8	1127.18	66.82	104.84	0	S52	285.26	51.49	-359.92	0
S168	-129.11	39.51	-715.47	0	S144	-4.55	73.87	-339.18	0

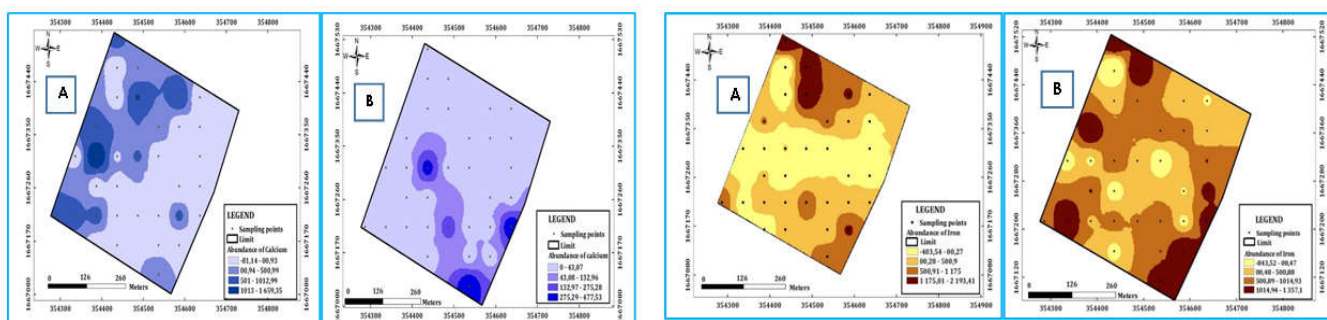
Iron toxicity appears the most often on soils with deficiencies in P, K, Ca, and Mg. It thus seems that an excess absorption of iron, toxic for the plant, is as much linked to a nutritional imbalance due to a low availability of P, K, Ca, and Mg in the soil, as to a high concentration of reduced iron soluble [28, 29, 30]. The figure 4 illustrates the elemental abundances, highlighting differences between the study site and the reference site.

The variations in calcium levels are apparent, ranging from -81.14 to 1659.35 ppm at the surface (0-20 cm), and in Figure 6B, from 0 to 477.53 ppm in the depth (20-40 cm). The profiles indicate a more substantial decrease at depth (20-40 cm) compared to the surface (0-20 cm). The observed calcium losses may be attributed to leaching, with drainage intensity influenced by precipitation (P) and evapotranspiration [31, 32]. Traditionally, calcium losses are indicative of base losses associated with soil acidification, as demonstrated in Figure 4.

Turning to iron differences in Figure 4, the surface (0-20 cm) shows variations from -403.54 to 2193.41 ppm, and at depth (20-40 cm), from -843.52 to 1357.1 ppm. Both surface and depth profiles exhibit losses, with more significant losses observed at depth (-843.52) compared to the surface (-403.54). Iron losses may result from water and wind erosion, with potential contributions from leaching and plant uptake. Noteworthy is the presence of iron deposits at both surface and depth, potentially linked to the application of iron-rich chemicals for crop enhancement.

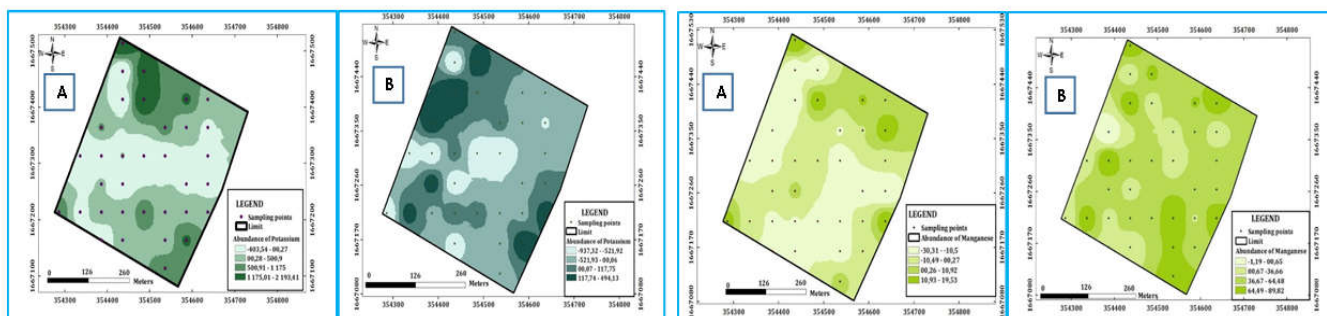
Abundances in potassium, depicted in Figure 4, range from -403.54 to 2192.41 ppm at the surface (0-20 cm), and from -937.32 to 494.13 ppm at depth (20-40 cm). Substantial losses are evident at both depths, with greater losses in surface samples, likely due to potassium's migration towards the soil surface. Causes for potassium losses include leaching, runoff, emissions, and plant utilization. Surface and depth deposits are also observed, with surface deposits being more significant, potentially influenced by soil texture and chemical applications for pest control and crop yield enhancement.

The manganese abundances vary from -30.31 to 19.53 at the surface (0-20 cm), and from -1.19 to 89.82 at depth (20-40 cm). A slight loss is noted at depth (-1.19), while a more substantial loss is observed at the surface (-30.31). These losses may be attributed to manganese's migration to plants through leaching or uptake. Additionally, both surface and depth deposits are observed, possibly resulting from sedimentation, physical and chemical sorption, or biological accumulation [33] as highlighted in Figure 4.



Difference in Calcium content compared to the reference: A-Depth 0-20 cm and B-Depth 20-40 cm

Deviation of iron content compared to the reference: A-Depth 0-20 cm and B-Depth 20-40 cm



Difference in Potassium content compared to the reference: A-Depth 0-20 cm and B-Depth 20-40 cm

Difference in Manganese content compared to the reference: A-Depth 0-20 cm and B-Depth 20-40 cm

Figure 4 : Abundance of Ca, Mn, Fe and K contents from 0-20 cm (A) and from 20-40 cm (B)

CONCLUSION

The interest of this characterization work falls within the current context of world agriculture because the quality of agri-food products is becoming increasingly important, particularly with regard to vegetable production. Thus, it is interesting to be able to recognize if a cultivated soil is free from contamination or, on the contrary, if it has kept track of potentially dangerous metal inputs and to clearly distinguish the part of what is natural (useful for plant) and what is contamination of human origin. This characterization study of essential elements for the soil was based on an application of already existing analytical methods in X-ray fluorescence spectroscopy and on the development of new procedures that can be used to determine the levels of heavy metals in the environment. For this, this study was carried out on the basis of an elemental analysis by energy-dispersive X-ray fluorescence. Thus, different types of soil samples were analysed. The variability of the Iron, Manganese, Potassium and Calcium contents of the different soil samples is explained by the fact that different factors were involved including the characteristic of the soil, the topology of the study site by the altitude slices, the topology of the site by contour lines and climatic conditions.

Finally, the different variability maps were conducted to classify the fertilization of the agricultural site based on the Fe, Mn, K and Ca contents. This method of mapping the contents of the essential elements for the soil is obtained on the basis of the ArcGIS 10.3 software which consists of upstream editing of UTM coordinate data over an area of 11 hectares.

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