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Farmers' Health and Contamination of Soils and Water in a Rural Area of Northeast Brazil

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ABSTRACT

Metals are widely present in the world due to natural and/or anthropic processes. They are used in several activities, mainly agricultural, generating concerns about their impact on health. To understand the health-disease processes of the population of this study, it was necessary to know the epidemiological profile and the distribution and magnitude of the health problems. The objective of this study was to correlate the presence of metals in agricultural soils with the epidemiological profile of the population, and to investigate the possible trace element contamination of the agricultural soils of the Natuba settlement, located in the city of Vitoria de Santo Antao, state of Pernambuco, Northeast Brazil. One hundred and two farmers participated and a specific collection instrument was applied to obtain exposure and risk results for chronic diseases. The chemical analysis of the soils was carried out by means of the Energy Dispersive X-Ray Fluorescence technique – EDXRF; the following trace elements were detected: Mn> Sr> Rb> Pb> La> Br. Besides these trace elements, and through the same technique, another four macroelements were analyzed: Si> Fe> Ca> Ti. Chronic diseases should be evaluated as a world health problem, requiring a preventive approach in association with these metals, so as to reduce pesticide dependence in agriculture, with proper monitoring of anthropogenic polluting sources.

Keywords: Trace elements; Enviroment; Health profile; Soil; Water microbiology

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INTRODUCTION

Soil contamination by chemical substances is characterized by undesirable changes in its physical, chemical and even biological properties. Human health is interlinked with soil quality, and thus to the degree of pollution. Contaminants deposited in the ground can dissipate, increasing their concentration in the air and, consequently, their absorption by the human respiratory system [1,2].

The application of agrochemicals to soils and crops has become a common practice in agriculture. These chemical substances allow for the control of weeds, insects and microorganisms that can damage crops and thus damage rural productivity. However, their use can cause chemical degradation, accumulation of toxic elements and/or compounds at critical levels in the soil, and the incidence of trace metals such as Mn, Zn, Co and Pb [2,3].

Although pesticides benefit agriculture through the appreciation of agricultural products, their widespread use has toxic effects on human health due to occupational and environmental exposure. Long-term contact with them can generate harmful consequences to human life by disrupting the function of the different organs of the body belonging to the nervous, endocrine, immune, reproductive, renal, cardiovascular and respiratory systems; contributing also to the incidence of chronic diseases, such as: cancer, Parkinson's disease, Alzheimer's disease, multiple sclerosis and diabetes [4-7].

Contamination by agrochemicals can occur through direct or indirect contact. Direct contamination occurs through the preparation, handling and use of the product, while indirect contamination may be a result of the ingestion of food and/or contaminated water. The interaction of rocks, air and water allows the polluted soil to transfer pollutants to surface water, groundwater, oceans, food chains, sediments, animals and humans [8,9].

The metals Cr, Cd, Mn and Ni, for example, may be included in the composition of harmful agrochemicals that accumulate within living organisms, causing serious diseases over time [8-10].

Phosphate fertilizers are a direct source of Cd contamination in agriculture and, because it is a long life element with slow excretion, its toxic effects in humans cause kidney failure and are possibly associated with hypertension. Similarly, Cr can also cause contamination in the thyroid artery and on the production of red blood cells, and cause polycythemia and coronary artery problems [11,12].

High doses of Mn and Cu can cause mental pathologies, such as Alzheimer's disease and manganism [13]. The Ni element can cause serious health problems, ranging from fatal heart attack, rashes, fatigue, headaches, heart problems, dizziness and respiratory disease. Zn is essential for the normal functions of the body and its deficiency can cause anorexia, diarrhea, dermatitis and depression, immune dysfunction and poor wound healing. However, its toxicity can lead to sideroblastic anemia [14].

In addition, contaminated soil by erosion, leaching caused by rainwater and the communication of water systems have helped to contaminate the water due to the use of agrochemicals, even when distant from the area of agricultural production. It should be noted that the contamination of a water system does not only represent problems in the use of water for agriculture, but also in the supply of a whole region and thus of the local population [15,16].

The World Health Organization considers exposure to these chemical compounds to be a public health problem, since more than three million people worldwide are contaminated annually and 80% of these contaminations develop into cancers. Contamination of the soil and the water sources by trace metals can impair the health of individuals, and due to the presence of these compounds in agrochemicals – and thus in agricultural activities – there is an urgent need to analyze the soil and water of rural areas; as it is important to identify the specific clinical aspects that compromise farmers' health [15-17].

Therefore the objective of the present study was to describe the epidemiological and clinical profile of the population and to carry out environmental analyzes of soil and water in the Natuba settlement, a rural area located in the city of Vitoria de Santo Antao, state of Pernambuco, Northeastern Brazil (Table 1).

EXPERIMENTAL SECTION

Study Population

This is an exploratory descriptive study with a quantitative approach carried out in the settlement of Natuba, Vitoria de Santo Antao-PE. The study population consisted of all the farmers enrolled in the Natuba Farmers' Association. The casuistry of the survey comprised 102 farmers selected after considering the following criteria: both sexes; older than 18 years; time of agricultural activity exceeding 5 years; and agreement to participate in the research through signature of the Written Informed Consent Form (WICF). Figure 1 shows farmers' distribution.

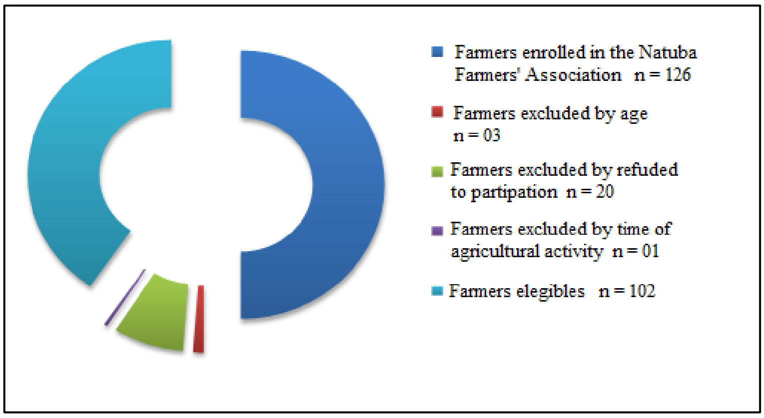

Figure 1: Distribution of farmers who participated in the study

Data was collected through an interview form containing sociodemographic, clinical and environmental risk information, and through physical examination, blood pressure (BP) and anthropometric measurements (weight, height, waist circumference and neck circumference).

To verify weight and height, an anthropometric digital scale was used, maximum capacity of 150 kg with precision of 100 g, as well as a portable stadiometer with precision of 0.1 cm.

Body mass index (BMI) was calculated from these measurements according to the following equation (1):[2]

$$BMI = \frac{weight\ (kg)}{height^2\ (cm)} \qquad (1)$$

The cut-off points of the BMI adopted were those recommended by the WHO [18]: low weight (BMI < 18.5); Eutrophy (BMI 18.5 - 24.99); Overweight (BMI 25 - 29.99) and obesity (BMI ≥ 30.00).

The abdominal circumference (AC) was obtained at the slimmest curvature localized between the ribs and the iliac crest, with a flexible and inelastic tape measure without compressing the tissues. When it was not possible to identify the slimmest curvature, the measurement was obtained considering 2 cm above the umbilical scar. The cutoff points adopted for AC were those recommended by Leanet et al. [19], according to the degree of risk for cardiovascular diseases: increased risk for women (AC > 80 cm) and for men (AC > 94 cm), and much increased risk for women (AC > 88 cm) and for men (AC > 102 cm). The neck circumference (NC) was measured with a flexible tape measure at the base of the neck, starting at the cricothyroid cartilage. In men with prominence, the NC was measured below the prominence [20]. With regard to the classification of neck circumference, the values used were <37 cm and >37 cm for men, and <34 cm and >34 cm for women, according to Ben-Noun et al. [21]. A calibrated mercury column sphygmomanometer was used to measure blood pressure (BP). The measurement was performed on the left arm following the proposals of the National Program for the Control of Hypertension [22]. BP classification was performed according to Chobanianet et al. [23], which considers four levels in mmHg: normal (systolic BP <120 or diastolic BP <80); Pre-hypertension (systolic BP between 120-139 or diastolic BP between 80-89); Stage 1 hypertension (systolic BP between 140-159 or diastolic BP between 90-99) and stage 2 hypertension (systolic BP ≥ 160 or diastolic BP ≥ 100).

Water Collection

Samples were collected at five randomly chosen sites: a well that supplies the farmers living in the lower part of the settlement; the water tank that receives the water that is pumped from the well; a faucet from a health unit; a river; and a residence in the upper part of the region which receives water controlled by the State Co., representing the 49 residences. The procedures for collecting, conserving, transporting and analyzing the water samples were carried out according to the recommendations contained in the Standard Methods for the Examination of Water and Waster Water [24]. In a sterile vessel, 100 mL of water were collected for microbiological analyzes, conditioned into isothermal boxes and immediately transported to the Microorganism Collection Laboratory of the Federal University of Pernambuco - Department of Antibiotics/UFPEDA. The microorganisms of the group of the total Coliforms and *Escherichia coli* [25] were investigated as bioindicators of microbiological contamination. To determine the integrity of the water, a count of the heterotrophic bacteria was carried out from the collected samples. The analyzes were performed according to the methodology of APHA, 2012 [24].

Soil Collection

Fifty-four soil samples were collected from seven locations in the study area at a depth of 0-25 cm, using a straight acrylic shovel. In each lot, samples were collected at the center and at the extremities (n = 5), at a distance of 75 meters from the central point. Sampling was performed in duplicate, totalling 10 samples for each quadrant. For comparison purposes, 2 soil samples were collected from an area not impacted by agriculture (natural). To evaluate the contribution of the dump, two samples were collected from the drainage channel. The samples were conditioned in polyethylene bags and taken to the Environmental Monitoring Service of the Regional Nuclear Science Center of the Northeast - SEAMB / CRCN-NE for processing. The analysis of elements Mn, Fe, Co, Ni, Br, Rb, Sr, Ti, La, Mg, Si, Ba, Pb and Ca, were performed in triplicate using the Energy Dispersive X-Ray Fluorescence Spectrometer – EDXRF, model EDX 720 from Shimadzu, which consists of a tube of rhodium for the generation of the X-rays, with a sealed chamber for the analysis of samples under vacuum and with a detector of Si (Li) for the quantification of incident radiation.

Data Analysis

For the epidemiological data the EPI Info Software version 8.1 was used; specifically, the descriptive statistical analysis expressed as percentage, and the Chi-square test (χ 2) to compare proportions to determine the "p" value at the significance level of 5%. The research was conducted within the standards required by the resolution of the National Health Council (CNS) No. 466/12, which deals with ethics in research with human beings; and the approval from the Research Ethics Committee of the Otavio de Freitas Hospital of the State Health Department, through the CAAE: 37093114.8.0000.5200, opinion no: 821,552. Epidemiological data was analyzed using the EPI Info Software, version 8.1, and the descriptive statistical analysis was expressed as percentage according to the frequency of each information collected.

RESULTS AND DISCUSSION

Health Evaluation of the Farmers

During the study period, 126 farmers were registered in the farmers' association, however only 102 participated in the survey, totaling a sample loss of 24 farmers who were excluded because they did not meet the inclusion criteria.

The majority of those investigated in this study had ages ranging from 25 to 45 years (80.4%). From the results found by Hall [26], age is an important factor that interferes in the muscular strength of a worker. According to Grandjean [27], workers aged 25 to 35 years are at their peak of muscle strength and work capacity, and thus are driven to activities of greater muscular effort. However, when a worker is over 40 years of age, he suffers a progressive deficit in his muscular capacity, with a decrease in muscle fibers and motor units, which are responsible for muscle strength.

Working time in agricultural production greater than 20 years (57.9%). Regarding the hours dedicated to this activity, this study showed that 30.4% of farmers worked more than 8 hours a day.

The study shows that the number of women (19.6%) is lower than that of men, due to the fact that activities such as caring for the house, food making and care of children and husbands are attributed to them. Thus the number of women who are part of the farmers' association is smaller, as was the case in Guérin [28]. This data is also corroborated in other studies involving farmers [29,30].

Regarding the risky behavior to human health analyzed in this study, the use of alcoholic beverages deserves emphasis as a habit of approximately 58% of the farmers, while 25.7% use cigarettes. Reuse of agrochemical packaging and the absence of the use of EPIS were also present at percentages of 12.8% and 40.2%, respectively (Table 2). The study showed that many farmers (40%) did not use personal protective equipment (PPE). In a study conducted in the state of Rio Grande do Sul, 100% (11) of the rural workers investigated who used agrochemicals did not use PPE [6]. The Ministry of Health indicates the correct and concomitant use of all personal protection equipment, and reinforces that the disuse of this protection increases the likelihood of intoxication and health problems [31].

Table 1: Epidemiological profile of the studied workers of the Natuba Settlement, 2016

Variable		N	%
Age range	22 – 45	60	59.8
	45 – 72	42	41.2
Sex	Female	20	19.6
	Male	82	80.4
	Illiterate	13	12.8
Education (years of study)	01-Apr	29	28.4
	04-Aug	47	46.1
	9 – 10	13	12.7
Time working in agriculture (years)	5 to 10	13	12.7
	11 to 20	30	29.4
	Above 20	59	57.9

Source: Natuba, 2015

In conjunction with other indicators (reuse of agrochemical packaging, smoking and alcohol consumption), non-use of PPE may be indicative of different types of chronic diseases. It is worth mentioning that agrochemical toxicity can be aggravated by these factors. According to the WHO [18], 36 million people died of chronic diseases from pesticides, 9 million being under 60 years of age. These are considered slow progression diseases, therefore long term health problems. However, they are the leading causes of death in the world, accounting for more than 60% of all deaths, especially in low-income countries [4].

Table 2: Distribution of farmers with health risks - Natuba-PE

Variables	N	%
Uses alcoholic beverages	59	57.8
Smokes cigarettes	26	25.7
Reuses agrochemical packaging	13	12.8
Does not use PPE during activity	41	40.2

Source: Natuba, 2015

The main clinical findings of the farmer population of this study are described in Table 3, with predominance of reports related to headaches (23.5%), dizziness (2.9%) and swelling of ankles and feet (2.9%). According to Hoshino et al. [32], subjective and constant symptoms from exposure to agricultural activity - associated to the use of pesticides - may represent early signs of intoxication, which may be confirmed from the results presented. His study also observed that these nonspecific signs and symptoms are present in several pathologies that many workers underestimate. They don't perceive a relation between their agricultural activity – including the use of pesticides – and the symptoms they have, and they consider that headaches, dizziness, epigastric pain, and others are natural processes resulting from their work.

Table 3: Clinical profile of the farmers of the Natuba- PE Settlement from October to December 2014

Signals and Symtoms	N	%
Headache	24	23.53
Nausea	2	1.96
Diziness	3	2.94
Fatigue	1	0.98
Loss of memory	1	0.98
Swelling of ankles, feet	3	2.94
Reduction of urine	1	0.98
Sleep disorder	2	1.96
Diarrhea	1	0.98
Epigastric pain	1	0.98
Dermatitis	1	0.98
Others	16	15.69

Fonte: Natuba, 2015

Obesity is one of the greatest public health problems in the world, and is associated with an increase in cardiovascular mortality [33]. Anthropometric indicators have been used to identify overweight and obesity. In 2011, the Ministry of Health published that 48.5% of the Brazilian population is overweight, the highest percentage being men at 52.6%, women corresponding to 44.7%. When comparing the sum of the results of overweight and obesity obtained by the BMI of the farmers, the study verified that 45 were male, and 13 female, corroborating with other published data [34].
Table 4 presents an analysis of the risks assessed for cardiovascular disease (body mass index, blood pressure, absominal circumference and neck circumference) according to the respondents. Neck circumference was the only variable that presented a significant statistical difference among groups (p = 0.000).
As for the anthropometric index of the AC, the risk is higher in men (n = 33) than in women (n = 18), and there is a correlation between an AC above the standard and an increased NC, confirming the findings by Ben Noun et al. [35]. Therefore, alterations in AC reflect the male standard of fat distribution and the changes in the risk factors for cardiovascular disease. When comparing the use of AC with this pathology, it was identified as having a strong association with this disease [36,37].
The results of the risk criteria for cardiovascular diseases, according to NC, showed that it was more pronounced in men (48.78%) than in women (25%). Hypertension, diabetes and dyslipidemias are associated with increased NC, and are also related to insulin resistance [35-41]. High blood pressure appears in 68 of the farmers in this study, increasing risk for cerebrovascular disease, coronary heart disease, congestive heart failure and chronic renal failure [42].
With regard to heart disease and pesticide exposure, the Oregon report presents an epidemiological study on the risks of coronary disease and the activity of the enzyme paraoxonase [43].

Table 4: Distribution of cardiovascular evaluation variables according to sex in the population of farmers of the Natuba- PE Settlement from October to December 2014

Varibles	Male		Female		X^2	p
BMI*	**N**	**%**	**N**	**%**		
< 18.5 (low weight)	2	2.4	0	0	3.49	0.321
18.5 – 24.99 (eutrophy)	36	43.9	6	30		
25 – 29.99 (overweight)	31	37.8	12	60		
≥ 30,00 (obesity)	13	15.9	2	10		
TOTAL	**82**	**100**	**20**	**100**		
AP**						
Normal	10	12,2	2	19	1.98	0.369
Limitrophe	31	37,8	11	55		
Hypertensive	41	50	7	35		
TOTAL	**82**	**100**	**20**	**100**		
AC (cm)***						
<80	12	14.6	2	10	0.67	0.954
80-88	22	26.8	6	30		
89-93	16	19.5	3	15		
94-102	19	23.2	5	25		
>102	13	15.9	4	20		
TOTAL	**82**	**100**	**20**	**100**		
NC (cm)***						
≤ 35	10	12.2	14	70	29.8	0
36 – 39	45	54.9	4	20		
>39	27	32.9	2	10		
TOTAL	**82**	**100**	**20**	**100**		

* BMI = Body Mass Index; ** AP = Aterial Pressure; *** AC and NC = Abdominal Circumference and Neck Circumference. Source:Natuba, 2015

Characteristics of Water Quality for Human Consumption

For approximately 70 years now microorganisms originating from feces have been used to interpret the degree of fecal pollution in water, since they are usually present in the excreta of humans as well as other vertebrates. Among these microorganisms, the bacterium *Escherichia coli* is considered the most important pathogenic indicator of fecal origin [44]. Water quality is an indispensable condition for the maintenance of life as it directly influences people's health [45]. The presence of faecal coliforms, including *E. coli*, in waters stored in clay pits is possibly associated with the precarious sanitary conditions of the community, since preventive measures are not taken to control the access of people and animals to these bodies of water, transforming them into continuous sources of contamination [46]. The result of the analysis of the water consumed by the population (Table 5), showed that the water treated by the state Co. responsible for its distribution maintains its quality until it reaches the farmers' homes. However, the residents that are supplied water through a well or river are subject to having their health compromised. This is made evident with the incidence of total coliforms and *E. coli* in results that are not admissible by the Ordinance No. 2914 [25], of the Ministry of Health of December 11, 2011 – even while results for heterotrophic bacteria were below 500 UFC/mL.

Chemical Analysis of the Soil

Soil chemical studies evaluate the distribution of the elements and the processes that govern the flows among different land typologies. Soil science evaluates the controlling factors of distribution, mobility and bioavailability of the chemical elements, from natural and anthropic sources. This in turn is important for geochemical studies and for the better understanding of the difference between the natural concentration of the elements and the effects of the Anthropic origin of these elements [47].

Table 5: Microbiological analysis of the water used for human consumption in the region of the Natuba- PE settlement from October to December 2014

Sample points	Total Coliforms	*E. coli*	Heterotrophic Bacteria
Well	+	+	27 Ufc/Ml
Water tank	+	-	54 Ufc/mL
Faucet	+	+	82 Ufc/mL
River	+	+	200 Ufc/mL
State Co.	-	-	115 Ufc/mL

Source: Natuba, 2015

By studying the soil-forming factors that influence the distribution of the elements, it is generally possible to separate natural variability, as the flows and the distributions of the material from their source to the soil will be linked to pedogenetic and geomorphological processes. The principal component analysis (PCA) was used to verify the correlations among chemical elements through principal components 1, 2 and 3. As a result of PCA, principal component 1 explained 31.10% of the total variance, while principal component 2 explained 22.20%, and principal component 3 explained 18.33%. For this analysis, two principal components were chosen, and this led to the explanation of 71.63% of the total variance of the data. Figures 2A and 2B shows the relationships among the principal components NC 1 × NC 2 (A) and NC 3 × NC 1 (B), demonstrating the association among the quantified chemical elements in the soils of the investigated quadrants. According to the analysis, groups of chemical elements were identified, such as Mn-Ti-Zn; Br-Ca-P-Sr; Co-Fe-V; La-Sr-Mn; Ca-Fe-P-Ni. It should be noted that the relationships among chemical elements were considered complex.

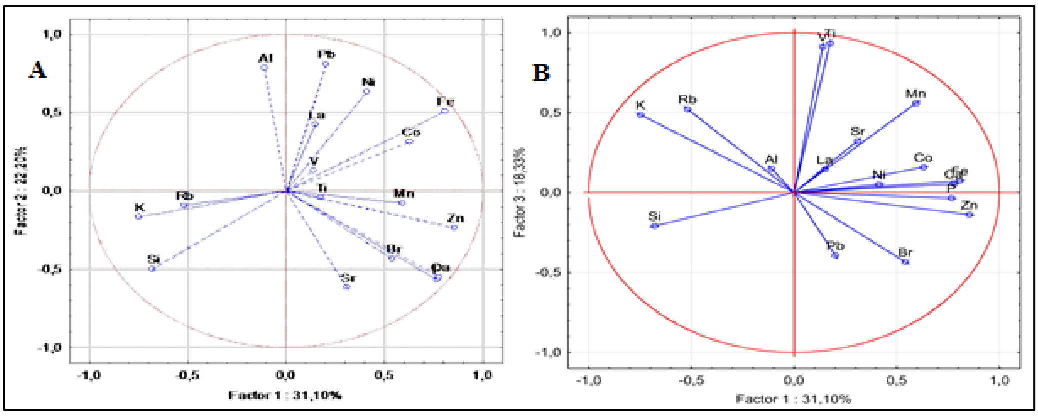

Figure 2: Grouping of the variables from the analysis by principal components. A) Values of principal components 1×2; B) Values of principal components 3×1

The formed groups observed through the principal component analysis may suggest a possible contamination of the soil, due to the association amongst the toxic elements. The relationship among the elements Mn-Ti-Zn may be associated to fertilizer use by the settlement's farmers, especially Ti, which is widely used in the production of pesticides and herbicides [48]. The groups formed by Co-Fe-V, as well as Ca-Fe-P-Ni may be interconnected due to the use of agrochemicals, since the chemical elements Co, Fe and Ni are found in the composition of fertilizers; however, Ca and P appear in the soil because they are used for correction. The presence of V is usually associated with Fe, but it is also present in mafic and ultramafic rocks that are rich in ferromagnesian minerals [49].

The association among the chemical elements Br-Ca-P-Sr and La-Sr-Mn, regarding the presence of calcium and phosphorus is related to their use in soil correction. Br is used in the form of methyl bromide as a fumigant for pest control, and can be found in the soils of the settlement. Sr is present in the air, soil, dust and surface water, aside from being an additive for diesel fuel. As the agricultural area is located at the margins of highway BR-232, which has intense flow of heavy vehicles, there may also be a correlation here. The presence of La is due to its use in fertilizers that are spread over the cultivated areas [48,49].

CONCLUSION

Human health can be affected by way of the environment, occupation and food, in association with socio-demographic and epidemiological factors. The contribution of the environment is of fundamental importance for the understanding of human illness. To these, other factors may be added, such as deficiency of technical assistance in rural areas, the difficulty of enforcing the law and the responsibility of the workers themselves, as contributors to the consolidation of the impact on human health which results from the use of agrochemicals - one of the largest public health problems in rural areas, especially in developing countries.

The study showed that the quality of water distributed by the state Co. presents acceptable standards, according to the ordinance of the Ministry of Health. However, the study also reported that there is a part of the population that is supplied by wells and the river, and by the same ordinance this water is considered unfit for consumption. Thus, it is necessary for Government entities to extend equal access to acceptable water to the entire population.
The results obtained by the Energy dispersive X-ray Fluorescence spectrometry (EDXRF) can be used to evaluate the modifications in the chemical elements present in the soil - which is submitted to different systems of use and management. The PCA showed association of chemical elements Mn-Ti-Zn; Br-Ca-P-Sr; Co-Fe-V; La-Sr-Mn; and Ca-Fe-P-Ni, quantified in the soils of the investigated quadrants, and these were linked to natural and anthropic alterations of the study region.
Thus, the importance of conducting an environmental and human study in agricultural areas contributes as an indicator for planning actions and measures to promote health and environmental care, and to reduce the population's exposure to risks.

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