



Pesticides in Soils using Satellite Imagery and their Possible Effects on Human Health in the City of Huamanga in the Year 2023

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The pesticide problem in the town of Muyurina, Huamanga, is evident due to the constant use of pesticides in local agriculture. This study aimed to understand the extent of pesticide contamination and its possible effect on human health. To do so, a methodology combining surveys and satellite image analysis was used. The surveys collected data on pesticide use and health problems in the local population, while the satellite imagery helped to identify areas of pesticide contamination. The results indicate that the pesticides detected match those commonly used in agriculture. Many villagers reported health problems possibly linked to exposure to these pesticides, reflecting World Health Organization warnings about the dangers of such exposure. In conclusion, pesticide contamination in Muyurina is a public health issue that needs to be evaluated, as these chemicals, used to protect crops, are contaminating the soil and could be affecting the health of villagers. This study highlights the need for more research in this area to confirm these findings and develop mitigation strategies.

Keywords: Contamination, Pesticides, Satellite Imagery, Health, Agriculture.

1. Introduction

The issue of pesticides in the locality of Muyurina, Huamanga, is alarming due to their intensive use in agriculture, leading to growing concerns about soil contamination and its effects on public health. The use of pesticides in agriculture is a globally significant economic activity; however, their persistence and environmental distribution can pose serious risks to human health [1]. Pesticides, designed to eliminate harmful organisms for crops, are associated with respiratory, dermal, and digestive diseases due to their presence in the environment. Exposure to these compounds can occur through air, food ingestion, and water, potentially causing both acute and chronic health effects. Acute exposure refers to brief contact with high

doses of pesticides, while chronic exposure involves prolonged contact with low doses, resulting in severe long-term diseases [1] [2].

In industrialized countries, pesticide residue monitoring in food is conducted continuously. Although pesticide control is more effective in these countries, food products with pesticide residue levels above the Maximum Residue Limit (MRL) have been reported. Numerous studies have shown that despite their widespread use, pesticides can cause significant adverse health effects, including cancer, reproductive abnormalities, neurological disorders, and respiratory diseases. Although laws and regulations exist to control their use, exposure to these chemicals remains a considerable challenge in many regions [3].

Detecting and monitoring contaminated soils is crucial for the treatment and prevention of diseases arising from pesticide exposure. In this context, satellite imagery emerges as a powerful tool to identify and monitor contaminated areas, providing precise information about the location and extent of contamination. According to German scientist Heinrich Hertz, electromagnetic radiation is produced when objects reach high temperatures. In the 19th century, Hertz demonstrated that energy could be characterized as massless particles traveling as waves over mutually perpendicular electric and magnetic fields [4].

This study focused on the locality of Muyurina, in the Huamanga province of the Ayacucho department, identifying pesticides present in the area using technological tools, specifically satellite imagery. Additionally, it aims to expose the potential effects these chemical compounds have on the health of the local population by applying surveys that gather non-numerical data to investigate complex phenomena such as behaviors, perceptions, and social responses. The study sought to determine: How are satellite images used to analyze pesticides in soils, and what could be their potential effects on human health in the city of Huamanga in 2023? Furthermore, what is the extent of pesticide contamination in the soil of Muyurina, and how does it affect the health of its inhabitants?

It is important to note that pests are unwanted plant or animal species that can disrupt any phase of the agricultural and food supply chain, from production to processing. The use of insecticides or pesticides is considered necessary to preserve the integrity of these foods and products during storage, transit, distribution, and processing. These chemicals perform crucial tasks such as regulating plant growth, defoliating, desiccating, reducing fruit density, and preventing germination. Additionally, these compounds are sprayed on crops both before and after harvest, primarily to protect the product from deterioration during storage and transport [5].

Currently, the use of pesticides in agriculture is a highly significant global economic activity. However, the persistence and environmental distribution of pesticides can lead to soil, water, and food contamination, posing a risk to human health [6].

2. Methodology

To identify pesticides in soils using satellite images, specifically using data from the Sentinel satellite, a detailed process is followed. First, multispectral images from Sentinel-2 are acquired, providing adequate spatial resolution to detect variations in the soil. The images are preprocessed by applying radiometric and atmospheric corrections to ensure the accuracy of

Nanotechnology Perceptions Vol. 20 No.S3 (2024)

the spectral data. Subsequently, remote sensing techniques are employed to identify spectral signatures characteristic of pesticides, using analysis of vegetation indices and reflectance. Areas identified as potentially contaminated are validated through in situ soil sampling and laboratory analysis to confirm the presence and concentration of pesticides. The data obtained are integrated into a Geographic Information System (GIS) to generate maps of pesticide distribution. Finally, a toxicological risk analysis is conducted to assess the potential effects on human health, considering the bioaccumulation of pesticides in the food chain and their impact on local communities. This integrated approach allows for efficient monitoring and precise evaluation of the risk to public health [7].

This research presents a qualitative approach classified as a basic type, as it uses satellite images to generate new knowledge. This approach emphasizes the collection of non-numerical data and focuses on investigating complex phenomena such as behaviors, perceptions, and social responses inherent to each study. Our sole purpose is to inform and disseminate knowledge through the use of technological tools applied in the development, which include passive and active sensors, satellites dedicated to earth observation such as Landsat and Copernicus, and the Sentinel constellation, applying spectral bands to capture information in various sections of the electromagnetic spectrum, allowing data to be obtained on various phenomena and qualities. These bands are fundamental in the acquisition and processing of data in the field of remote sensing [8].

Information from satellites orbiting at approximately 36,000 km altitude, known as "Geostationary" satellites, was applied. They are primarily used in meteorology. Due to their distance from the equator, they can capture images of the entire world every day. However, this advantage has a drawback: the enormous distance reduces the sharpness and detail of the captured photographs. Heliosynchronous satellites, these specific satellites, orbit at altitudes ranging from 600 to 800 km, are called "quasi-polar," as they move near the poles. Although the satellite takes many days to pass over the same place again, this orbit provides good spatial resolution [9].

With the aim of identifying the types of pesticides present in contaminated soils through surveys, similarities and differences were observed in two of our backgrounds. We were able to identify the most used pesticides in their respective study areas; Malathion was the most predominant in Mala, Peru, while Taramon and Parathion were the most common in Huacrapuquio-Huancayo.

Red, green, and blue bands were used to create a natural-looking color. Using near-infrared, red, and green bands to produce a false-color image. Utilizing the red, near-infrared, and mid-infrared regions to create a pseudo-natural color. A mixture of 25% pseudo color and 75% true color. It is essential to highlight the importance of satellite image acquisition methods for the precise and effective advancement of research, including photogrammetry and remote sensing [10].

The study does not seek to explain the causes of the relationships but to measure individual variables. In this case, the phenomenon under examination is the use of pesticides and their potential effects on human health. Satellite images were considered to identify pesticides in the study area [6] [11].

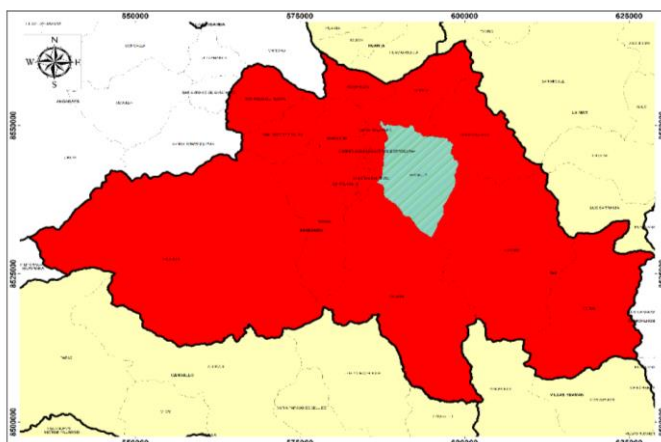


Figure 1: Location map of the study area.

The health of the inhabitants was measured through surveys that collected information on health conditions and access to health services. Pesticide detection has been carried out using satellite technology, providing data on their location, extent, and concentration.



Figure 2: Image of the study area with sentinel 2-8

According to the National Institute of Statistics and Informatics (INEI), the province of Huamanga - Ayacucho has 324,901 inhabitants. The data were entered into Microsoft Excel 2016 using descriptive statistics. To compare results, descriptive statistical methods were employed with the [12] programs.

Table 1. Microsoft Excel y SPSS 26.

Satélite	Datos	Polarization /Bandas
<u>Sentinel-1</u>	Radar	VV, HH, VV+VH, HH+HV
<u>Sentinel-2</u>	Multispectral	10 bands
<u>Sentinel-3*</u>	Multispectral	21 bands
Satélite	Datos	Polarization /Bandas
<u>Sentinel-1</u>	Radar	VV, HH, VV+VH, HH+HV

Where the results obtained through the main instrument are presented and discussed. To identify the types of pesticides present in contaminated soils, the results of our survey were

used. This analysis examined how pesticides are used in the agricultural area of Huamanga-Muyurina, considering factors such as age, gender, and educational level.

This research was conducted to determine the pesticides present in the population center of Muyurina, Huamanga province, Ayacucho department, using data and technological tools, which in this case are satellite images. Additionally, it aimed to expose the possible effects of these chemical compounds on the health of the population of Muyurina town, Huamanga. The following table details the 20 selected documents that meet the inclusion criteria.

A systematic review of scientific literature was conducted, involving 40 documents, from which a total of 20 research papers were selected. Information was gathered by searching bibliographic databases or electronic repositories in the following databases: Scopus, Dialnet, Google Scholar, ProQuest, Redalyc, ScienceDirect, Alicia, and Scielo.

Table 2. Analysis and classification of research

BASE DE DATOS	DOCUMENTOS TOTALES	DOCUMENTOS INCLUIDOS
Alicia	1	1
Dialnet	1	2
Google academic	2	1
ProQuest	1	1
Redalyc	2	1
Scopus	4	10
Scielo	2	3
ScienceDirect	2	1
total	15	20

3. Results

The survey results indicated that many residents of Muyurina experienced health problems that could be related to pesticide exposure, such as headaches, respiratory issues, and skin diseases. Analysis of satellite images showed significant areas of pesticide contamination in the soil. Although our results demonstrate a correlation between pesticide exposure and certain health problems, it is crucial to emphasize that our study does not establish a definitive causal relationship. There may be other unmeasured variables that could potentially contribute to these health issues.

The analysis shows a relationship between age and the duration of pesticide exposure. 2.76% of individuals aged 17 to 25 were exposed for 10 minutes; this percentage increases to 9.68% for those aged 26 to 35 and further increases to 14.75% for those aged 36 to 50. The most typical exposure time for both genders is around 10 minutes, with 21.20% of men and 5.99% of women from all exposures.

Considering the level of education, it is notable that for individuals with only secondary education, the most typical exposure time is also 10 minutes, representing a significant 14.75% of cases [13] [14].

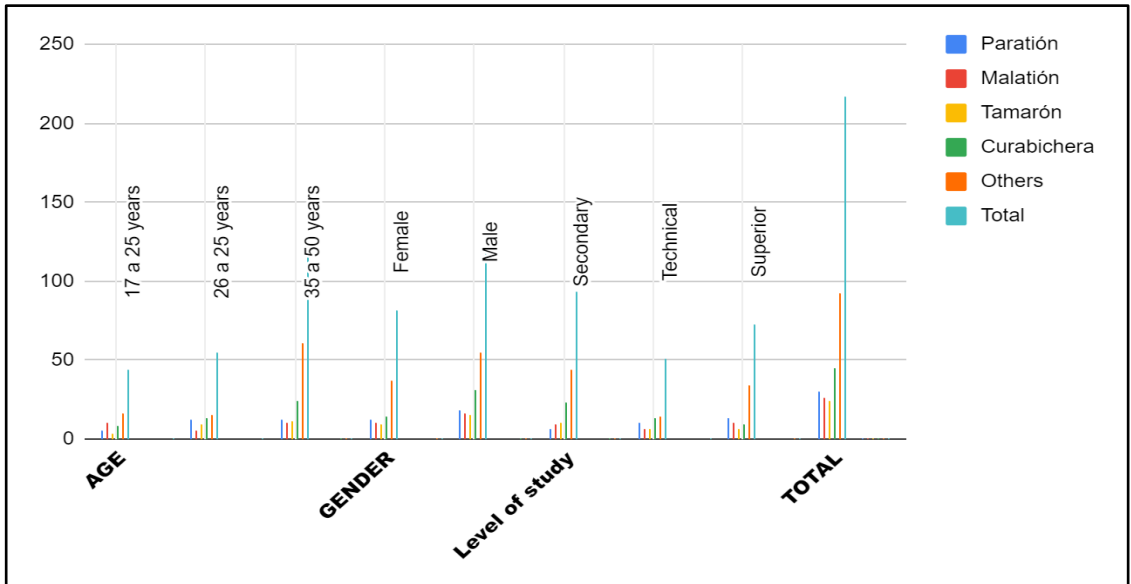


Figure 3: Most used pesticides

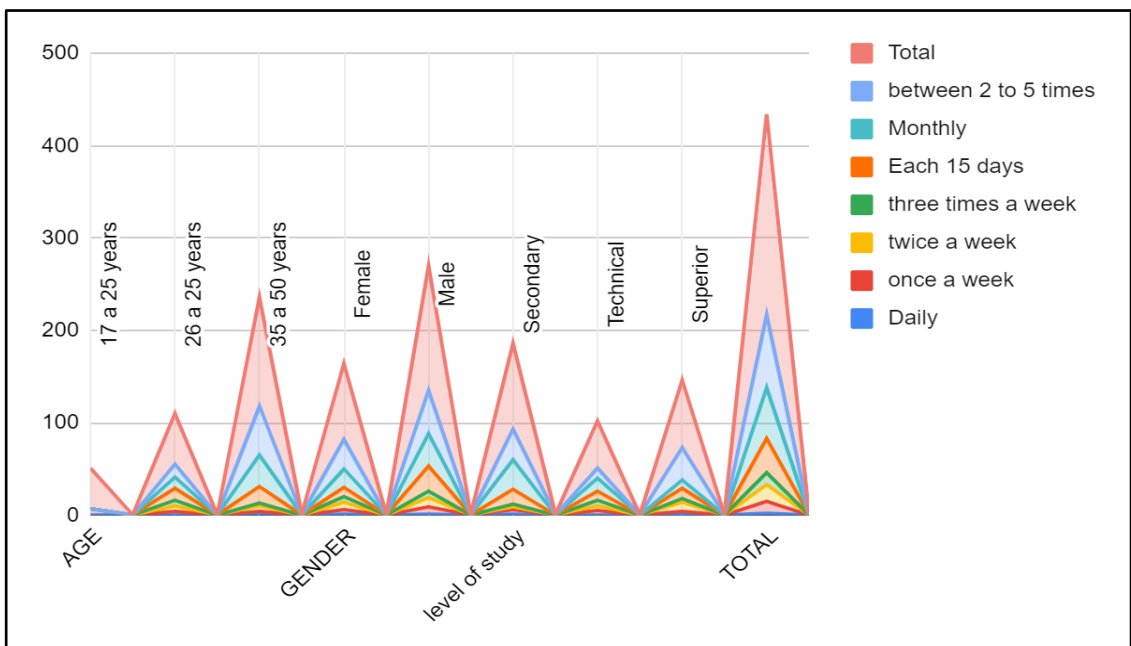


Figure 4: Time of Use of Pesticides

24.42% of individuals aged 36 to 50 use pesticides for 2 to 5 months. 21.66% of men and 14.75% of women use pesticides during this time. Among those with university education, 16.13% use pesticides during this period.

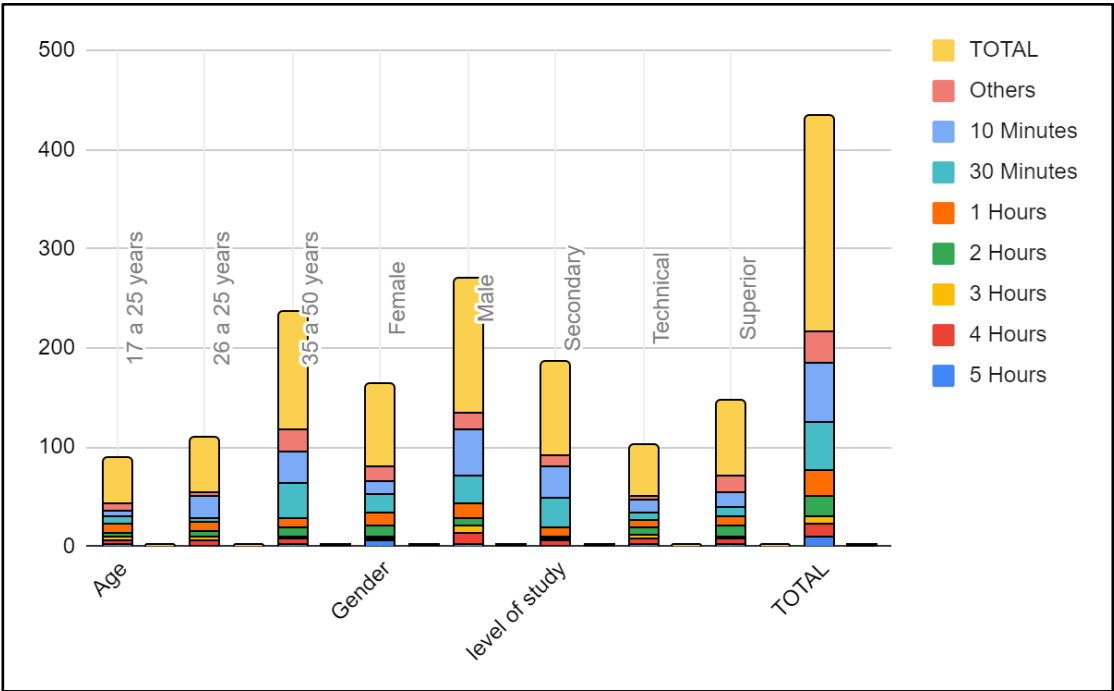


Figure 5: Pesticide Exposure Time

14.75% of individuals aged 36 to 50 are exposed for about 10 minutes. 21.20% of men and 5.99% of women have this exposure. For individuals with secondary education, 14.75% have a 10-minute exposure. These percentages show the magnitude of pesticide use and exposure to them in different demographic groups in the agricultural area of Huamanga-Muyurina.

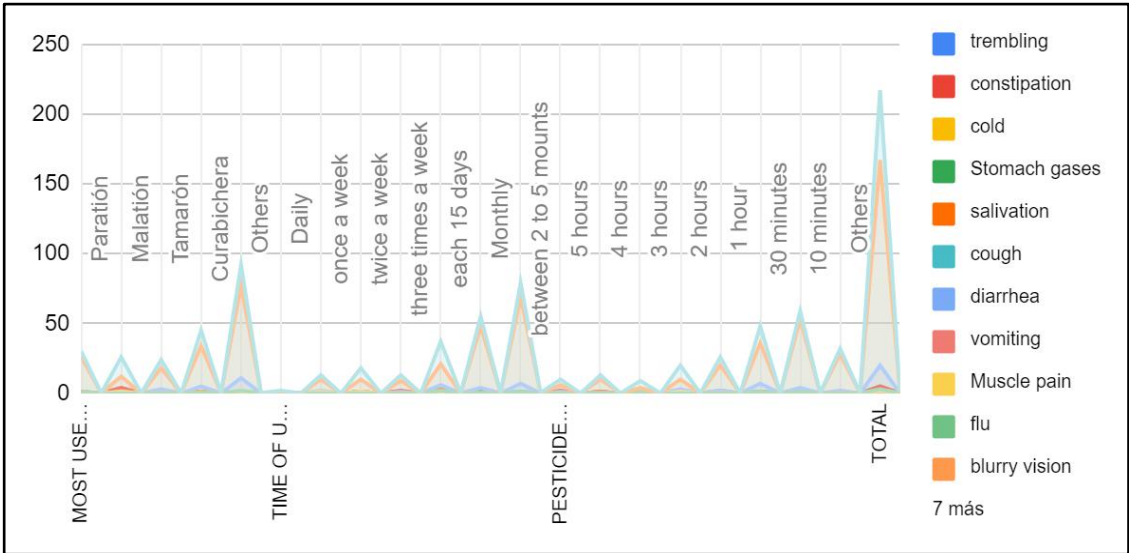


Figure 6: Symptoms of the population before exposure to pesticides

According to the data, the most commonly used pesticide by these farmers is Curabichera, representing 0.46% of the total. Other crucial criteria were also considered, such as the timing of pesticide application and the exposure period. Regarding the frequency of application, it was found that farmers using the pesticide twice a week accounted for 2.3% of all cases. Finally, considering the duration of exposure, it was shown that the group of farmers exposed for 4 hours constituted 2.3% of the cases. These statistics are important for understanding the relationship between pesticides, their use, and the potential issues they pose in the agricultural sector [15].

4. Discussion

It is noteworthy that the most commonly used pesticide is curabichera. Its use varies according to age: more people between 36- and 50-years old use it. Men use it more than women. Curabichera is the most commonly used pesticide, representing 0.46% of the total. 11.06% of individuals between 36- and 50-years old use it, while 3.69% of young people aged 17 to 35 and 5.99% of young adults aged 26 to 35 use it. 14.29% of men and 6.45% of women use curabichera. Among those with secondary education, 10.6% use it. To support the results of pesticide residue tests in food, systematic techniques and methods must be used to allow for extraction, isolation, identification, and quantification. Globally, the problem with pesticides lies in the lack of adherence to the standard for the indiscriminate use of these pesticides internationally and nationally by producers, who use these chemical compounds. The norms that are broken pertain to the hygiene and safety when applying these pesticides to the soil. This problem is also related to the lack of political will of the authorities and as a result, it has caused the intoxication of many workers dedicated to agriculture, as well as the contamination of water sources, the environment, and has caused an imbalance in the ecosystem [16].

It has been demonstrated that pesticides produce ecotoxicological impacts on various environmental factors, such as water, air, soil, and living species. The lack of selectivity of pesticides is one of the main problems related to their use. When dispersed in the environment, their toxic effect extends beyond the target pests to other species. It is believed that 99% of residual pesticides harm countless invertebrates that are part of animal biodiversity, even though they are not the target of chemical control [17].

In 2012, two products between pesticides and related insecticides were registered in the National Agrarian Health Service (SENASA), with broad-spectrum products being the most commercialized, including metamidophos and chlorpyrifos. In 1981, based on studies, the use of chlorophyll was presented on the western coast of France [3]. Petro Kogut, a physicist and mathematician in 1998, explained two theses that had a significant impact on the use of satellite imagery in agriculture, which dealt with "The stability and Optimal stabilization of neutral delay-differential equations."

The pesticides detected in satellite images corresponded to the types of pesticides commonly used in the agriculture of Muyurina. Correlations between reported health problems and the presence of pesticides suggest a possible link. Comparison with previous studies These results are consistent with previous studies linking pesticide exposure to various health problems.

Impact: Pesticide contamination poses a significant risk to the public health of Muyurina.

Limitation: The study was limited to self-reported data and image analysis, which may influence and limit the accuracy of pesticide detection. Recommendations for future research: More detailed studies with direct pesticide detection methods and in-depth health analysis are needed to confirm these results. Pesticide contamination in Muyurina is a public health problem that requires urgent assessment.

5. Conclusion

In conclusion, pesticide contamination in Muyurina is a public health problem that needs urgent evaluation. The results underscore the need for further research and the development of mitigation strategies to protect the health of residents.

According to surveys conducted in the locality of Muyurina, Huamanga-Ayacucho in 2023, the most commonly used pesticide in contaminated soils appears to be Curabichera, especially among individuals aged 36 to 50, men, and those with secondary education. Additionally, pesticide use tends to last between 2 and 5 months, especially in the same demographic group. However, further research is needed to confirm these findings and to explore more deeply the reasons behind these trends.

In order to identify the types of pesticides present in contaminated soils through surveys, similarities and differences were observed in two of our backgrounds. We were able to identify the most commonly used pesticides in their respective study areas; Malathion was the most predominant in Mala-Peru, while Taron and Parathion were the most common in Huacrapuquio-Huancayo.

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