International Journal of Innovative Research and Scientific Studies, 8(6) 2025, pages: 1296-1308

IJIRSS
International Journal of Innovative Research & Scientific Studies

ISSN: 2617-6548

URL: www.ijirss.com

Water pollution by urban solid waste and microplastics in a rural community in the state of Guerrero, Mexico

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Abstract

The purpose of this study is to assess the environmental and public health impacts caused by inadequate urban solid waste (MSW) management and the presence of microplastics in Las Ánimas, a rural community in Guerrero, Mexico, with a special emphasis on water resource contamination. The methodology, a mixed-methods approach with an explanatory, cross-sectional, and multi-scale design, was employed. The methodology integrated geospatial analysis of open-air dumpsites, physical characterization of waste according to Mexican standards, in-depth interviews with local stakeholders, and visual identification of microplastics in the digestive tracts of poultry. The spatial proximity between dumpsites and water sources was analyzed using GIS tools and aerial drone imagery. Findings reveal a high per capita MSW generation (0.5566 kg/person/day) and the existence of 24 informal dumpsites, many of which are located near springs, agricultural fields, and residential areas. Plastic waste represented a significant fraction of the total waste composition. Microplastics were visually identified in the digestive systems of free-range chickens, indicating their integration into the local food chain. These findings demonstrate that rural communities are not exempt from the environmental impacts of plastic pollution and that current waste disposal practices compromise water quality, public health, and ecosystem services. In conclusion, the study provides evidence that unregulated MSW disposal in rural areas causes severe environmental degradation, including water pollution and the spread of microplastics to food systems. The integration of geospatial tools, biological indicators, and local socio-environmental data underscores the need to review public policies that have traditionally focused on urban areas. Practical implications highlight the urgent need for inclusive, community-based waste management strategies that incorporate environmental education, local governance, and appropriate technologies. Policymakers must address the specific conditions of rural environments by designing interventions that reduce the dispersion of solid and emerging pollutants while protecting key ecosystem services and food security.

Keywords: Community-based management, ecosystem services, environmental health, food safety, microplastics, municipal solid waste, open dumpsites, rural pollution.

DOI: 10.53894/ijirss.v8i6.9910
Funding: This study received no specific financial support.
History: Received: 16 July 2025 / **Revised:** 20 August 2025 / **Accepted:** 22 August 2025 / **Published:** 18 September 2025

Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Institutional Review Board Statement: The Ethical Committee of the Universidad Autónoma de Guerrero (UAGro), Mexico, has granted approval for this study on 1 May 2025 (Ref. No. 026).
Publisher: Innovative Research Publishing

1. Introduction

In rural environments, the improper disposal of solid waste significantly compromises water resources, both surface and underground, due to leachate infiltration and runoff. This problem is especially critical in regions where communities rely on local springs, rivers, or shallow wells for domestic and agricultural uses. In such contexts, the proximity of open dumpsites to water bodies directly exacerbates contamination and undermines water security.

The inadequate management of municipal solid waste (MSW), along with the growing accumulation of microplastics in ecosystems, represents a significant threat to environmental sustainability, especially in rural communities that depend directly on ecosystem services [1]. These services such as the provision of drinking water, soil fertility, climate regulation, disease control, and the preservation of traditional cultural practices are essential for both human well-being and ecological balance [1, 2].

In many developing regions, the absence of structured waste management systems has led to informal practices such as dumping in streets, water bodies, agricultural lands, and open burning [3]. These actions contribute to soil and water pollution through leachates, the emission of greenhouse gases, the proliferation of disease vectors, and the risk of flooding due to drainage obstruction [4]. These problems are exacerbated in rural areas, where nearly half of the global population lives without access to technical tools or adequate infrastructure, favoring the emergence of open-air dumps (TCA). In Mexico, this situation has intensified, as MSW generation increased by 30.26% over the past decade, while population growth was only 15.17% [5].

In Latin America, the lack of environmental institutionalization, deficient infrastructure, and limited culture of waste separation have worsened the problem, especially in rural communities, where informal dumps predominate [6, 7]. Among waste types, plastics constitute a critical factor due to their high persistence and low recycling rates, which result in direct consequences for human health, soil fertility, and the functioning of ecosystem services [8].

An emerging issue associated with plastic waste is its fragmentation into microplastic particles smaller than 5 mm, which can be ingested by aquatic and terrestrial organisms, including those intended for human consumption [9]. Although this phenomenon was initially believed to be limited to marine and urban environments, recent studies have documented its presence in rural, agricultural, and livestock contexts, where social and environmental vulnerability conditions increase their effects [10, 11].

These microplastics not only persist in the environment but also act as vectors for organic and inorganic contaminants, increasing their toxicity and complicating remediation efforts [12, 13]. Moreover, they affect key ecosystem functions by reducing soil fertility, altering ecological dynamics, decreasing biodiversity, and deteriorating air and water quality [14]. Even remote rural communities, as evidenced in a coastal Venezuelan community, can exhibit microplastic levels up to 1,197 times higher than some Latin American urban centers, revealing the direct impact of poor waste management [15, 16].

Because these regions are often excluded from public policies on integrated waste management, significant gaps in information, control, and planning are generated [17]. Therefore, it is essential to understand the local dynamics of waste generation, dispersion, and impact in order to design sustainable strategies that integrate community knowledge, strengthen local governance, and mitigate socio-environmental risks [18].

Community participation is essential to address these challenges. Various studies have shown that participatory planning, the promotion of recycling, and environmental education are effective tools for reducing the impacts of waste in rural areas [19]. These practices also promote greater environmental awareness and strengthen sustainable territorial governance [20].

However, a gap remains in the scientific literature regarding the issue of MSW in rural areas from a comprehensive perspective [21]. This highlights the urgent need to develop research that provides technical and social evidence for the formulation of more inclusive and effective public policies [22].

One of the communities where this problem is most clearly manifested is Las Ánimas, in the municipality of Tecoanapa, Guerrero [23]. The absence of collection services has led to the proliferation of open-air dumps and the burning of waste, with impacts on public health, soil and water contamination, and the degradation of natural habitats [4].

In this context, the present study analyzes pollution from municipal solid waste (MSW) and microplastics and their impacts on ecosystems and human health in Las Ánimas, municipality of Tecoanapa, Guerrero.

2. Materials and Methods

To assess the potential impact on water resources, spatial analysis was emphasized to evaluate the proximity of waste disposal sites to natural water bodies, including springs, streams, and wells used for domestic and agricultural purposes. Although direct water sampling was beyond the scope of this study, qualitative field observations and geospatial correlations were employed to identify areas at high risk of contamination from leachates and runoff.

This research employed a mixed methods approach with an explanatory design. A non-experimental, cross-sectional, and multiscalar design was used, integrating geospatial analysis, physical waste characterization, qualitative interviews, and environmental assessment through bioindicators.

2.1. Study Area

The study was conducted in the rural locality of Las Ánimas, located in the municipality of Tecoanapa, Guerrero, Mexico (16°58'17.388" N; 99°19'10.618" W). This community exhibits high levels of marginalization, a subsistence economy, and lacks formal infrastructure for MSW management, making it a representative case for analysis (Figure 1) [5].

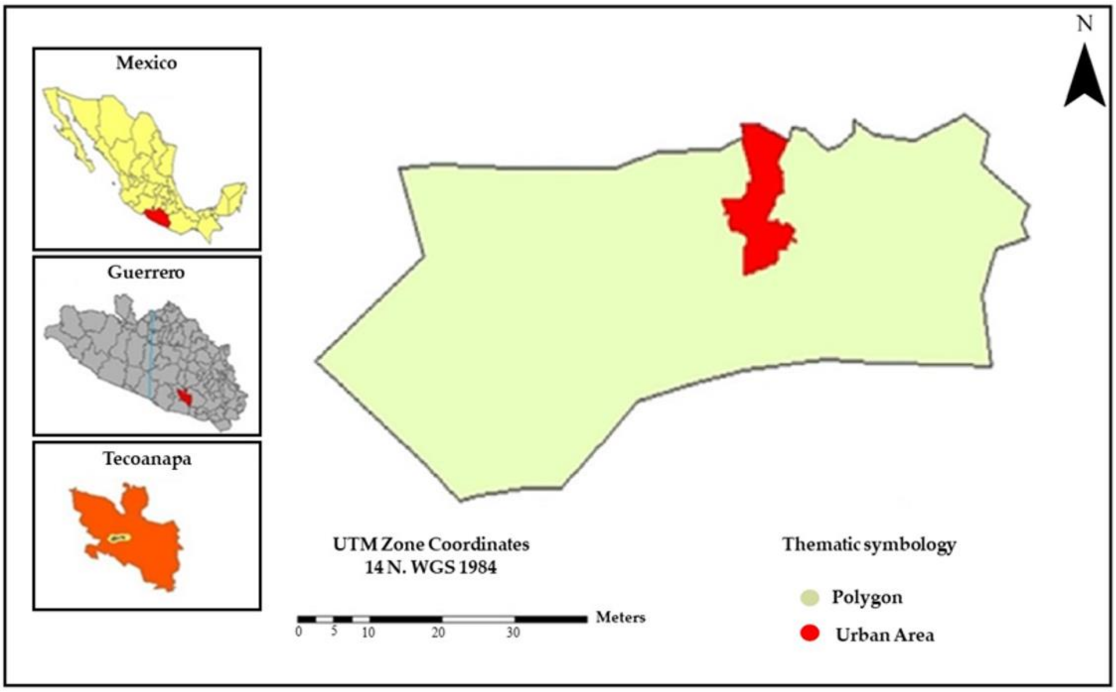

Figure 1.
Las Animas, Municipality of Tecoanapa, Guerrero, Mexico.

2.2. Estimation of Per Capita MSW Generation

Thirty households were randomly selected across four representative neighborhoods. For seven consecutive days, household waste was collected in coded polyethylene bags, which were weighed daily using a precision digital scale (±1 g). The collected data were used to calculate the daily per capita waste generation and its intra-weekly variability.

2.3. Physical Waste Characterization

The characterization was carried out according to Mexican Standard NMX-AA-015-1985, using the quartering technique. Waste was classified into the following fractions: organic matter, plastics, textiles, metals, paper, glass, and others. Special attention was given to the visual identification of fragments with morphology consistent with microplastics.

2.4. Georeferencing and Mapping of Open-Air Dumps (TCA)

Twenty-four open-air dumps were identified using a portable GPS device (Garmin GPSMAP 64s). The data were processed in Geographic Information System (GIS) software ArcGIS 10.8 to generate thematic maps illustrating their proximity to water bodies, agricultural zones, and households. Additionally, high-resolution aerial images were obtained using a DJI Phantom 4 Pro drone.

2.5. Assessment of Microplastics in Poultry

The contents of gizzards from backyard chickens slaughtered prior to local festivities were collected. The material was extracted by visual inspection with a stereoscopic magnifying glass Karl Zeiss®; the particles were classified by shape, color, and size according to other studies [24, 25].

2.6. Study Limitations

Visual observation in the analysis of microplastics limits the identification of the polymer from which they were manufactured. It is recommended to continue analyzing the samples, incorporating spectroscopic techniques such as FTIR or Raman to elucidate the most common polymers and their toxic potential for animal and human health in rural areas.

3. Results

A significant proportion of the identified open-air dumpsites were found adjacent to natural water sources, such as springs and ravines, indicating a direct risk of surface and groundwater contamination. The rainy season amplifies this risk, facilitating the transport of leachates from exposed waste into water bodies that serve as vital resources for the local population. These findings highlight the vulnerability of rural water systems to pollution from unregulated solid waste disposal.

Urban solid waste (USW) generation in the locality of Las Ánimas ranged from 0.420 to 0.660 kg/person/day, with an average of 0.5566 kg/person/day. This corresponds to an estimated annual production of 317,948 tons. Although this value falls within the expected range for rural communities in developing countries, it exceeds the figures reported in other localities within the same municipality.

This per capita generation may be closely linked to the composition and characteristics of the waste identified during the characterization process. In the case of Las Ánimas (Figure 2), the fraction with the highest accumulation percentage was organic matter (30%), followed by fine dust (14%), plastics (10%), glass (10%), cardboard and paper (9%), and metals (5%).

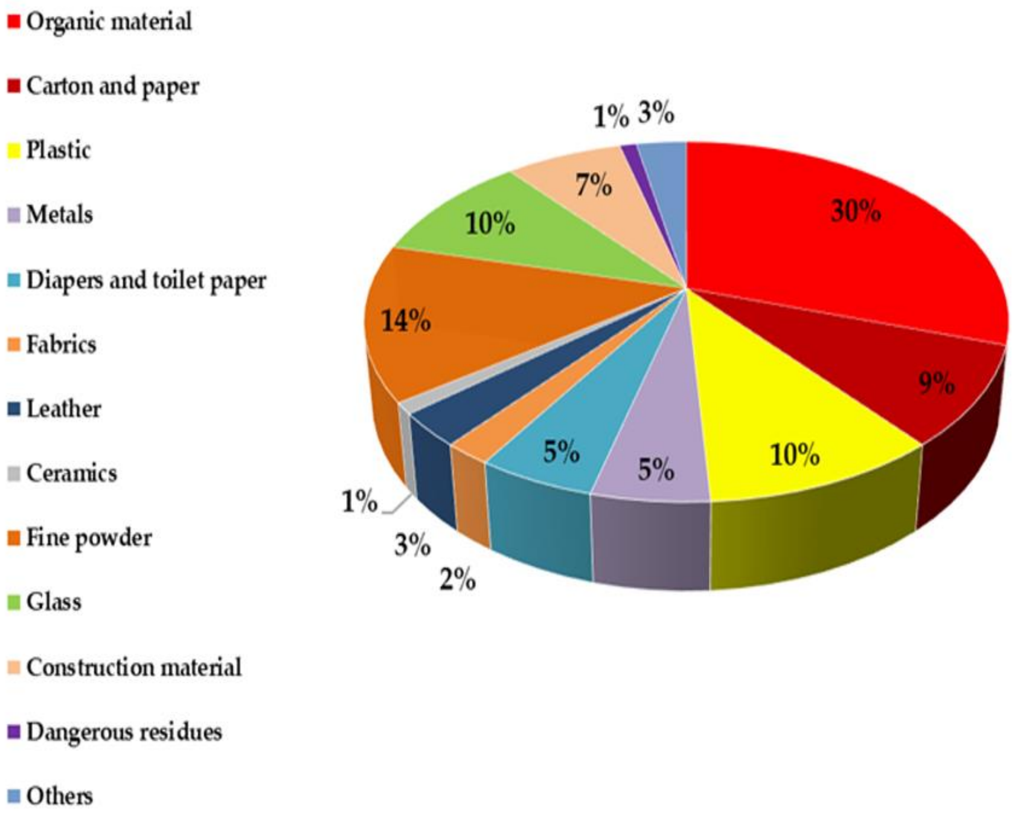

Figure 2.
Generation of urban solid waste (USW) in the locality of Las Ánimas, municipality of Tecoanapa, Guerrero, Mexico.

In addition to household waste generation, 460 active economic units were identified as complementary generators of municipal solid waste (MSW) in the locality (Table 1). These units encompass a variety of sectors, including retail businesses, educational services, food establishments, and community centers. For example, grocery stores generate waste such as cardboard, PET plastic, bags, and glass; whereas establishments such as stationery shops, internet cafés, pharmacies, and clothing stores generate paper, plastic packaging, and other inorganic waste.

Similarly, educational institutions in the locality from kindergarten to high school generate both organic and inorganic waste of various types. The coexistence of households and economic units in an environment without a formal system for segregated waste collection increases the environmental burden on uncontrolled disposal sites. This situation complicates comprehensive waste management and highlights the need for community-based strategies that take into account the diversity of waste-generating sources.

Table 1.
Economic units and types of waste generated.

Economic Unit	Total	Type of Waste Generated
Households	421	Organic and inorganic waste (Various types)
Grocery stores	13	Cardboard, plastic bags, PET, glass
Hardware stores	1	Metals, plastic bags, PET, cardboard
Pharmacies	2	Cardboard, plastic bags, PET
Stationery shops	3	Cardboard, plastic bags
Cyber	2	Paper sheets, electronic devices, PET
Clothing stores	7	Plastic bags, cardboard
Food vendors	3	Food scraps, bags, disposable cups and plates
Church	1	Dried flowers, glass, paper
Municipal Office	1	Paper sheets, cardboard
Cultural center	1	Paper sheets
Tortilla shop	1	Organic waste, paper, bags
Kindergarten “Juana de Arcos”	1	Organic and inorganic waste (Various types)
Elementary School “Damián Carmona”	1	Organic and inorganic waste (Various types)
Secondary School “Juan N. Álvarez”	1	Organic and inorganic waste (Various types)
High School No. 20 “Las Ánimas”	1	Organic and inorganic waste (Various types)
Total	460	

During field visits, 24 open dumpsites (TCA) were identified and georeferenced in the locality of Las Ánimas (Figure 3). These sites, which collectively receive approximately 0.871 tons of USW per day, are located in alarming proximity to water bodies, agricultural land, urban infrastructure, and conservation areas, demonstrating a direct impact on local ecosystems.

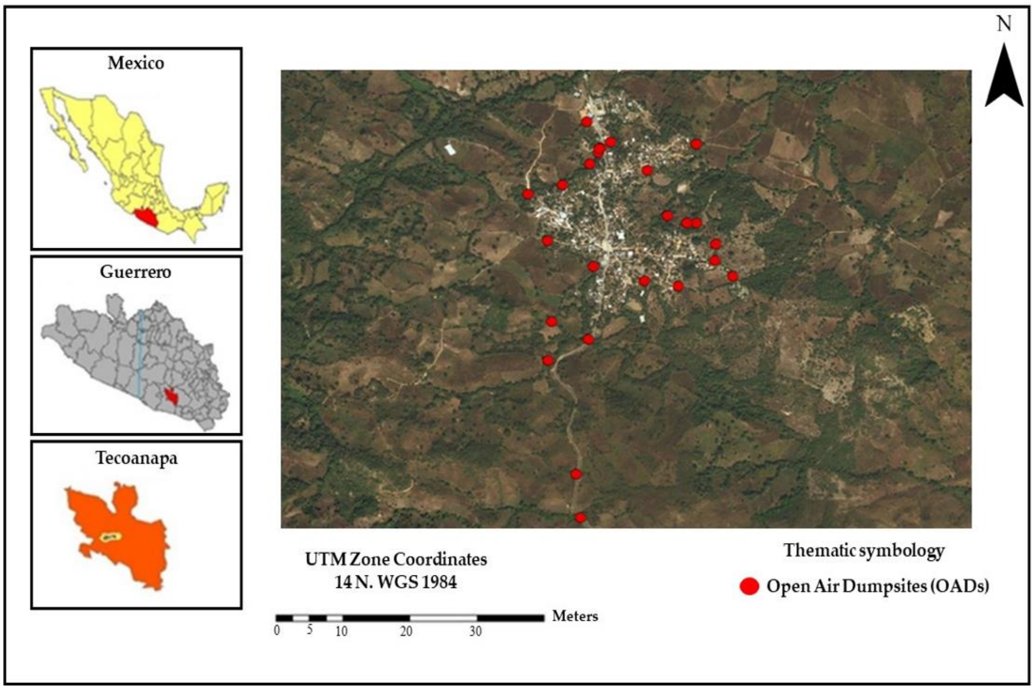

Figure 3.
Geographic location of the 24 Open Dumpsites (TCA) in Las Ánimas, Municipality of Tecoanapa, Guerrero, Mexico.

It was observed that at least 45% of these dumpsites are situated near natural water bodies such as streams, ravines, or springs (e.g., TCA 1, 2, 3, 4, 6, 9, 10, 11, 14, 22, 24). In many of these cases, waste is transported downhill during the rainy season, increasing the risk of both surface and groundwater contamination [24, 25]. Particular concern is warranted for the “Los Cuartololotes” spring, which serves as a local water source and is threatened by the direct discharge of leachate and graywater (TCA 2, 9, 10, 11, 24) [26] (Figure 4).

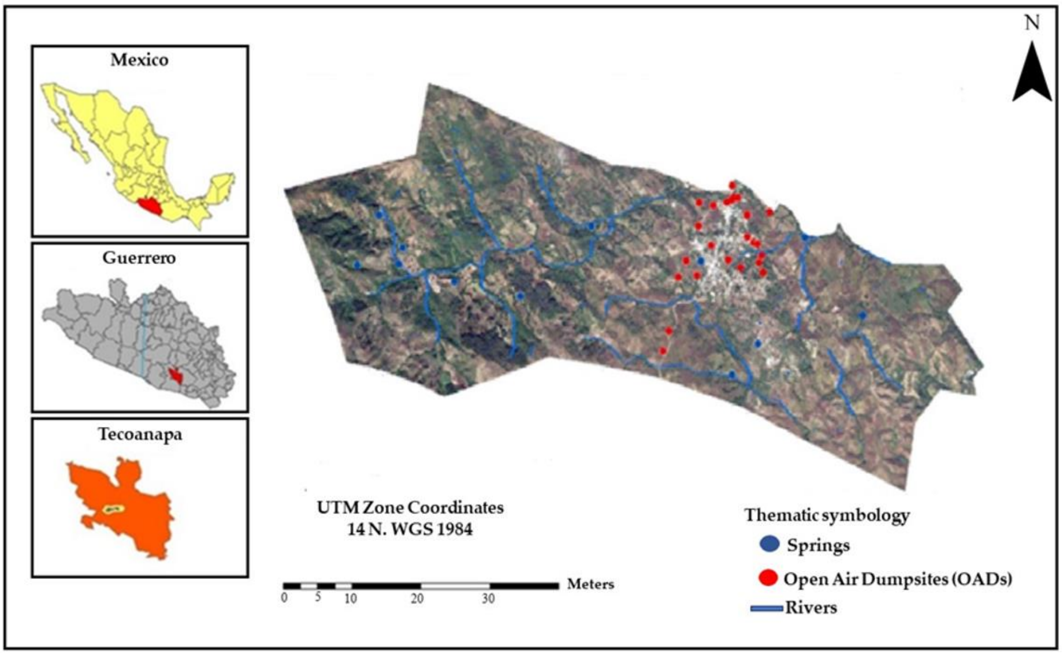

Figure 4.
Geographic location of the 24 Open Dumpsites (TCA) in Las Ánimas, Municipality of Tecoanapa, Guerrero, Mexico.

Moreover, more than 60% of the open dumpsites (TCA) are located on or near agricultural land, leading to soil degradation, loss of fertility, and an increased risk of contamination by microplastics, heavy metals, or pathogens. Notable examples include TCA 5, situated near a poultry farm, and TCA 3, adjacent to a water well used by the local population [26].

Additionally, the proximity of these dumpsites to residential areas and educational institutions (TCA 1, 2, 6, 15, 16, 17) poses significant health risks to the population, contributing to gastrointestinal, respiratory, and dermatological diseases associated with continuous exposure to decomposing organic waste and airborne pollutants [27].

Ultimately, the observed pattern suggests that improper waste disposal not only directly impacts aquatic and agricultural ecosystems but also threatens the ecological connectivity of the landscape by introducing pollutants into groundwater recharge zones and wildlife corridors, thereby undermining the sustainability of provisioning, regulating, and supporting ecosystem services.

The image presented in Figure 5 was captured using an unmanned aerial vehicle (UAV) and shows an open-air dumpsite for municipal solid waste located on the outskirts of the locality. The site is adjacent to a secondary road that connects the communities of Las Ánimas, Huamuchapa, Villa Hermosa, Ocotitlán, and El Techalé, facilitating vehicle traffic and promoting the continuous and improper disposal of waste by local residents.

Along the right side of the road, scattered piles of waste were identified, composed mainly of plastics, textiles, and household refuse, extending along the slope. The surrounding area is predominantly agricultural, with dense vegetation and cultivated fields clearly established on both sides of the roadway.

At the far left of the image, a ravine with denser vegetation is visible, confirming the presence of an active natural watercourse that connects downstream to springs and artisanal wells used by the local population. This proximity poses a verified environmental risk, as leachates generated by the waste are transported by surface runoff during the rainy season, contaminating nearby water sources [28, 29].

The use of aerial technology enabled a clear characterization of the scale of the problem, revealing both the extent of the disposal site and its integration into the agricultural and natural landscape, which intensifies the direct environmental impacts on soil, water, and associated ecosystem services [30] (Figure 5).

Figure 5.
Open-air dumpsite location, on the side of the Las Ánimas–El Techalé highway.

Figure 6 shows another urban solid waste disposal site located on a slope adjacent to a traveled roadway. The presence of vehicles and pedestrians confirms the site's accessibility, which facilitates the recurring dumping of waste by local residents. A significant accumulation of household waste was observed, mostly inorganic materials such as plastics, textiles, and containers, disposed of directly on the ground without any form of containment or technical control.

The dumpsite lies on a downward-sloping surface with dense vegetation, posing a high risk of surface runoff during the rainy season. This condition may lead to the transport of waste and the infiltration of leachate into lower areas, representing a direct threat to soil quality and groundwater. The site's proximity to agricultural areas also poses a risk to the health of the productive ecosystem, as physical and chemical pollutants could enter the agricultural cycle, affecting food safety and environmental sustainability [4].

The open-air dumps become potential hotspots for harmful fauna and disease vectors, representing a latent health risk for people passing through or living nearby. The lack of waste management infrastructure at the site reflects the absence of control strategies by municipal or community authorities, perpetuating the use of these areas as informal dumping grounds [31].

Overall, the image reveals a multifactorial environmental issue, where road accessibility, the absence of formal waste collection systems, and a lack of awareness regarding ecological and health risks converge. Addressing this situation requires comprehensive interventions that not only include the closure and remediation of the site but also the strengthening of solid waste management through a community-based and territorial approach.

Figure 6.
Final disposal site for urban solid waste located on a slope adjacent to a road.

Figure 7 shows an agricultural area with seasonal crops such as maize and hibiscus (Jamaica), along with grazing animals, specifically goats, feeding on partially fenced land with shrub vegetation. This area exhibits typical characteristics of a subsistence farming system, where small livestock are raised on open plots with spontaneous vegetation.

In the foreground, there is a considerable accumulation of solid waste scattered across the land, representing a significant source of soil contamination and a health risk for the grazing animals in the area. The direct interaction between the waste and the agricultural environment reflects improper waste management, resulting in negative effects on both crop and livestock production. These impacts may include contamination of forage, obstruction of crop growth, harm to animal health, and the introduction of microplastics or toxic substances into the food chain [32].

Figure 7.
Agricultural area with seasonal crops such as corn and hibiscus (Jamaica), and grazing goats on partially fenced land with shrub vegetation.

The following image (Figure 8) documents a highly vulnerable environment, where a cultivated area is observed alongside a significant accumulation of organic and inorganic solid waste scattered across the ground. Among the waste, plastic materials, plant residues, containers, and household garbage stand out, creating a visible pollution hotspot. This open dumpsite is located in close proximity to a dwelling visible on the right side of the image, posing a considerable health risk to residents due to the proliferation of disease vectors, foul odors, and the degradation of the immediate surroundings.

Figure 8.
Open-air dump near a home.

Additionally, direct interaction was observed between poultry and other domestic animals feeding among the waste, representing a significant health threat, as these animals ingest contaminated materials, including microplastics present in the environment. The ingestion of microplastics by birds not only compromises their health but also poses a potential food safety risk by entering the human food chain through the consumption of contaminated meat.

In the background of the image, denser vegetation can be seen, suggesting the presence of a natural watercourse (stream), which receives polluted runoff from the dumpsite (leachates), especially during the rainy season. This condition poses a critical risk to surface water quality, which is used by the community for domestic and agricultural purposes [33].

Overall, the scene documents a serious environmental and health issue involving water contamination from leachates, the spread of waste into agricultural areas, zoonotic risks due to animal waste interaction, the dumpsite's proximity to homes, the ingestion of microplastics by domestic animals, and the progressive degradation of the soil.

In absolute terms, Las Ánimas generates between 0.870 and 0.936 tons of municipal solid waste (MSW) per day, amounting to more than 317.95 tons per year [23]. While these figures may seem modest compared to more densely populated urban areas, their relative impact is significant due to the lack of formal collection and final disposal systems. The situation becomes even more critical when considering the presence of informal dumpsites, proximity to agricultural areas, and the absence of infrastructure for proper waste management.

This diagnostic highlights the need to design differentiated waste management strategies for rural communities like Las Ánimas, taking into account not only the volume of waste generated but also the socio-spatial conditions that amplify its environmental impacts. Furthermore, it suggests that public policies must stop assuming that rural areas produce low amounts of waste and begin integrating more specific indicators to enable efficient interventions in these territories.

As a result of the visual analysis performed on the gizzard contents of the sampled hens, particles with characteristics consistent with microplastics were clearly and consistently identified (Figure 9). These findings provide direct evidence of environmental exposure to plastic contaminants and confirm the presence of such compounds in animals raised under traditional free-range systems. The coincidence between the location of open-air dumpsites (TCA) and the immediate environment in which these birds develop suggests a direct relationship between unregulated waste disposal practices and the incorporation of microplastics into the animals' digestive systems [34].

This result reinforces the hypothesis that TCAs serve as a significant source of environmental pollution in rural areas, facilitating the dispersion of plastic particles that are eventually ingested by domestic animals. The presence of microplastics in the digestive tract of poultry intended for family consumption highlights a potential transfer process into the rural food chain, representing an emerging risk to both animal health and food safety, as well as to human health.

Figure 9.
(a) View of the opened chicken gizzard; (b) Petri dish containing the contents of the chicken gizzard, composed of organic matter and microplastics.

4. Discussion

The degradation of water quality resulting from informal waste disposal is particularly alarming in Las Ánimas, where communities depend on nearby springs and wells. The proximity of dumpsites to these water sources, combined with seasonal rainfall patterns, increases the potential for infiltration and runoff of hazardous substances, including microplastics and other contaminants. This situation not only affects human health but also threatens agricultural production and local biodiversity dependent on these aquatic ecosystems.

Pollution resulting from the inadequate management of municipal solid waste (MSW) limits social well-being and compromises ecosystem services. According to the World Bank, global MSW generation increased from 1.3 billion tons in 2012 to 2.1 billion in 2016, and it is projected to reach 3.4 billion tons by 2050, an increase of 70% [35]. This growth is driven by population increase, changes in consumption patterns, and disparities in waste management infrastructure [36, 37].

In Mexico, per capita MSW generation varies depending on the context. Cities such as Celaya (Guanajuato) and Puerto Vallarta (Jalisco) exceed 0.6 kg/inhabitant/day, while in areas such as Fresnillo (Zacatecas) and Chilapa (Guerrero), it fluctuates between 0.41 and 0.50 kg/inhabitant/day (Table 2). These figures reflect deficiencies in waste collection and sanitation, particularly severe in marginalized rural communities such as Las Ánimas, where the absence of formal waste management services exposes the population to environmental and health risks [38].

Table 2.
Household per capita generation in several municipalities of federal entities of Mexico.

Federal entity	Municipality	Household per capita generation in kilograms per inhabitant per day
Guanajuato	Celaya	0.728
	Irapuato	0.646
Guerrero	Buena Vista de Cuellar	0.537
	Chilapa de Álvarez	0.505
Jalisco	Guadalajara	0.508
	Puerto Vallarta	0.624
Sinaloa	El Rosario	0.599
	Angostura	0.579
Zacatecas	Fresnillo	0.416
	Guadalupe	0.596

Source: Semaren [38].

The data obtained in Las Ánimas are consistent with other studies conducted in the state of Guerrero, where in rural areas such as El Pericón, waste generation reaches 0.691 kg/inhabitant/day [39], even surpassing urban figures (Table 3). This finding supports the hypothesis that rural areas, despite their low population density, can generate waste at levels comparable to or even higher than those of urban areas.

Table 3.
USW generation index in urban and rural areas, in the state of Guerrero, Mexico.

Source	Place	Environment [40]	Number of inhabitants [5]	USW generation index kg/inhab/day	USW Ton/day	USW Ton/year
Nava-Uribe, et al. [41]	Xaltianguis	Urban	6564	0.4	2.626	958.344
Nava-Uribe, et al. [41]	Tierra Colorada (Juan R. Escudero)	Urban	12262	0.344	4.218	1539.617
Nava-Uribe, et al. [41]	Las Mesas (San Marcos)	Urban	2803	0.396	1.110	405.146
Nava-Uribe, et al. [41]	Tecoanapa (Tecoanapa)	Urban	4590	0.379	1.740	634.958
Chupín-Hermenegildo, et al. [39]	El Pericón (Tecoanapa)	Rural	1688	0.691	1.166	425.739
Chupín-Hermenegildo, et al. [39]	Las Animas (Tecoanapa)	Rural	1565	0.598	0.936	341.593

The lack of waste collection, documented in both urban and rural contexts, leads to the proliferation of informal dumping sites [23, 42, 43]. These open-air dumps (TCA), located in ravines, agricultural fields, and urban peripheries, cause severe contamination of water, air, and soil. The leachates generated by the decomposition of waste and their interaction with rainwater affect both surface and groundwater sources [44-46].

In addition, the burning of waste in TCAs produces carbon dioxide, the primary greenhouse gas, as well as toxic compounds that cause respiratory problems and other health conditions [47]. Alterations in soil structure and fertility have also been observed, along with the absorption of microplastics by plant roots, further aggravating the situation [27, 28].
Microplastic pollution represents a growing threat. Recent studies have detected their presence in food products such as vegetables, beer, honey, sugar, seafood, and both tap and bottled water [48-51]. These particles have also been identified in livestock and poultry manure, demonstrating their entry into the rural food chain [52]. In this study, microplastics were visually detected in the gizzards of native chickens.

It has been found that humans ingest significant amounts of microplastic and nanoplastic particles, especially through the consumption of fish and seafood [53-56]. In terrestrial ecosystems, these contaminants can also be transferred through the food chain. In rural settings, domestic animals such as poultry, goats, and cattle are at risk of ingesting microplastics incidentally, either through direct contact with waste or by feeding in contaminated areas [31, 34].

However, a more in-depth analysis is required to determine the types of microplastics present and assess their potential deposition in skeletal muscle, in order to evaluate their effects on muscle development and the sanitary quality of the meat produced. Ultimately, microplastic contamination represents a direct threat to public health. The simultaneous presence of contaminated water, degraded soils, and food containing microplastics increases the vulnerability of rural communities. This situation is particularly concerning for individuals with chronic illnesses or pre-existing health conditions, who may be more susceptible to the adverse effects of these environmental contaminants.

5. Conclusions

This study reveals that informal waste disposal practices contribute significantly to the degradation of rural water resources, elevating risks of contamination in surface and groundwater used for essential human and agricultural needs. Addressing these impacts requires integrating water protection into rural solid waste management strategies, including the identification of critical water sources and the implementation of protective zoning and remediation plans.

The results obtained demonstrate that the inadequate management of municipal solid waste (MSW) in rural contexts such as Las Ánimas, Guerrero, represents a significant threat to ecosystem services, public health, and environmental sustainability. The high per capita waste generation, combined with the lack of infrastructure and institutional strategies, has led to the emergence of open-air dumps and the burning of waste, intensifying soil, air, and water pollution.

Moreover, the presence of microplastics in components of the local food chain, such as poultry, confirms that these particles have reached rural terrestrial ecosystems, posing potential risks to both human and animal health. This finding underscores the need to include rural environments in research on microplastic pollution, which has traditionally focused on marine or urban settings.

The evidence generated in this study highlights the urgency of designing public policies aimed at integrated waste management in rural communities, as well as the incorporation of participatory approaches that strengthen local environmental governance. Sustainable strategies are needed that integrate environmental education, source separation of waste, and appropriate technologies to reduce the dispersion of solid and emerging pollutants such as microplastics.

This study contributes to the body of knowledge on solid waste and microplastic pollution in rural areas and emphasizes the need for future research focused on the chemical characterization of these contaminants and the assessment of their implications for food security and public health.

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