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Health Risk Assessment of Irrigation Water used for Vegetable Farming from the Tilé Stream in the Urban Municipality of N'Zérékoré (Republic of Guinea)

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Abstract

In the forest region of Guinea, the shortening of the rainy season has driven market gardeners to use wastewater from the Tilé stream for irrigation, exposing workers and consumers to significant health risks. This study combined physico-chemical, microbiological, and parasitological analyses of irrigation water with surveys and focus group discussions involving 250 market gardeners (65 men, 99 women, 86 children) to assess practices and associated diseases. Physico-chemical analyses revealed elevated water temperatures (25.46-7.49°C) exceeding the WHO recommended range (10-25°C) in most sites, along with slightly acidic pH values (5.14-6.63). Microbiological and parasitological assessments showed a high prevalence of waterborne pathogens, with typhoid fever affecting 58.89% of men, amebiasis 31.52% of children, scabies 25.99% of women, syphilis 26.39% of adult men, infectious diarrhea 48.05% of children, and bacterial dysentery 50% of women.

These findings highlight the urgent need to incorporate irrigation water management and market gardening practices into public health policies to reduce pathogen exposure and protect vulnerable populations.

Keywords: Irrigation water, Market gardening, Public health risk, WHO, Tilé Stream

Introduction

Access to safe and good-quality water has become a major global concern due to the increasing number and diversity of pollution sources of both anthropogenic and natural origin. In many African cities, vegetable farming represents an important economic activity, generating income for vulnerable populations (particularly women and youth) while meeting the growing demand for fresh produce (Sou, 2009; Cissé, 2004). However, the limited availability of clean water resources is leading more and more producers to use surface water or wastewater as alternatives for irrigation.

The use of wastewater in agriculture is an ancient practice that has expanded with rapid urbanization, population growth, and mounting pressure on water resources. In several African cities, domestic, industrial, and artisanal effluents are often discharged untreated into watercourses, creating significant public health risks (El Addouli *et al.,* 2012). Microbiological and chemical contamination of these waters degrades their quality and restricts their use, particularly when they serve to irrigate vegetable crops that are consumed raw.

Concerns regarding water quality now extend beyond microbiological purity to include physicochemical characteristics and the presence of micropollutants such as heavy metals, which may accumulate in living organisms through bioaccumulation (Djermakoye, 2005). Heavy metals, even at low concentrations, pose major risks to human health and the environment, while industrial and artisanal effluents constitute an important source of long-term contamination.

In the Urban Municipality of N'Zérékoré in Forest Guinea, urban environmental degradation is reflected in increasing unsanitary conditions, poor waste and wastewater management, and the uncontrolled expansion of vegetable farming (Zinsou *et al.,* 2025). This situation promotes the spread of waterborne diseases such as typhoid fever, intestinal parasitoses, and other infections (Guilavogui *et al.,* 2023). Rural-to-urban migration, combined with the growth of polluting industrial activities, further intensifies pressure on water resources (Ben Abbou *et al.,* 2014).

Vegetable farming, a key activity for food self-sufficiency in N'Zérékoré, relies heavily on irrigation water, especially during the dry season when producers resort to multiple water sources, including small channels and rivers. One of the major risks associated with the use of wastewater or contaminated water is the prolonged survival of pathogenic microorganisms on crops (Ntangmo *et al.,* 2019). Several studies have reported the presence of bacteria, viruses, and parasites in wastewater used for irrigation, which can cause diseases such as typhoid fever, diarrhea, or parasitoses (Keraita *et al.,*2008).

Using polluted water for vegetable irrigation exposes not only farmers but also consumers, especially when produce is eaten raw. Health crises linked to poor effluent management and the use of contaminated water have been documented in various contexts. It is therefore essential to characterize the quality of irrigation water in order to assess potential health risks and propose mitigation measures (Ofori *et al.,* 2025).

In this perspective, the present study aims to assess the health risks associated with the use of water from the Tilé stream for irrigating vegetable crops in the Urban Municipality of N'Zérékoré, focusing on its physicochemical, microbiological, and parasitological quality, as well as farmers' practices that may influence these risks.

Materials and Methods

Study area

This study was conducted in the watershed of the Tilé stream, which originates in Galaye, northeast of the Urban Commune of N'Zérékoré (UCZ), and extends over approximately 10.67 Km across the city. The investigation focused both on the stream itself and on the surrounding areas where its water is abstracted for vegetable crop irrigation, particularly in the neighborhoods of Belle-Vue, Dorota, Wessoua, Tilépoulou, Kwitéyapoulou, Commercial, Mohomou, Gbangana, Nakoyakpala, and Nyen (Figure 1).

Tilé, the main source of irrigation water for these neighborhoods, directly receives solid and liquid waste discharges from various anthropogenic activities.

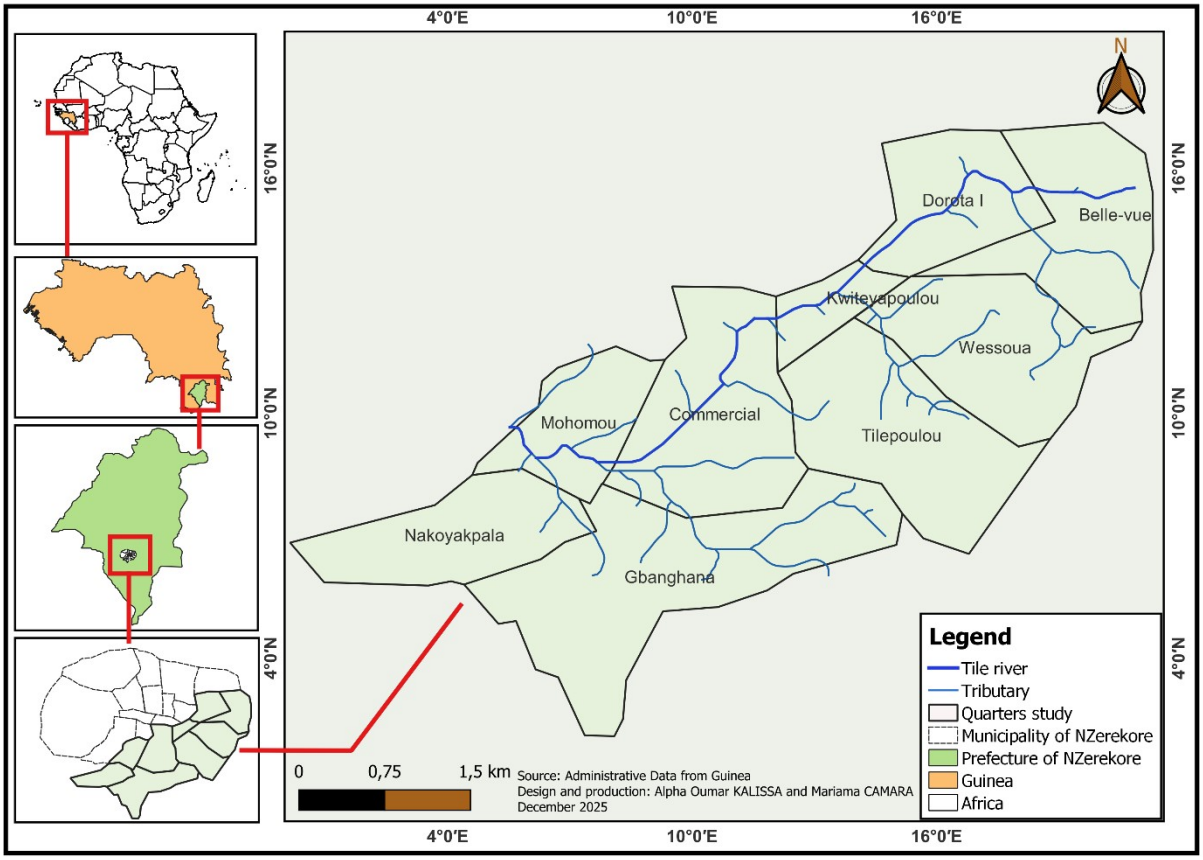

Figure 1 : Location of the study area and the main irrigation neighborhoods along the Tilé stream

Data Collection and Analysis

The data collection focused on two main aspects: the quality of the water used for irrigating vegetable crops and the practices of farmers as users of this water. To assess water quality, 20 samples of 100 mL each were collected to capture the spatial variability of the Tilé stream and its associated vegetable farming areas: two samples upstream, two downstream, and two samples from each of the ten neighborhoods crossed by the Tilé (Belle-Vue, Dorota, Wessoua, Tilépoulou, Kwitéyapoulou, Commercial, Mohomou, Gbangana, Nakoyakpala, and Nyen). The samples were stored in sterile containers, transported under controlled temperature conditions, and analyzed at the Analytical and Organic Chemistry Laboratory of the University of N'Zérékoré, allowing for an accurate assessment of the water quality actually used for irrigation.

Physicochemical Parameters

The measured parameters included pH and temperature, which were determined using electrometry with a waterproof multi-parameter device (HANNA Instruments, HI 98194, 2015 version).

Microbiological and Parasitological Analysis

The microbiological quality of the water was assessed through the enumeration of total and fecal coliforms, which serve as indicators of pollution and potential contamination. The method employed was membrane filtration, followed by incubation on solid media for 24 to 48 hours. Colonies formed were counted per 100 mL and expressed as colony-forming units (CFU/100 mL).

For inoculation, samples were diluted, boiled, and then placed onto Petri dishes prepared under aseptic conditions. The membrane containing the microorganisms was positioned on the culture medium, labeled, and incubated at 30°C. Colony counts were performed using the POTALAB+ (M) kit.

Identification of Gram-positive and Gram-negative bacteria was conducted after centrifugation of the samples. Bacterial pellets were deposited on slides, fixed, Gram-stained, and observed under a binocular optical microscope.

Parasitological analysis focused on the detection of parasitic worms (eggs or larvae). Pellets obtained after centrifugation were examined under an Olympus microscope at magnifications of 4X, 10X, 40X and 100X.

Data Collection from Farmers

A survey combining questionnaires and focus groups was conducted with 250 farmers across the ten vegetable farming areas supplied by the Tilé stream. The surveyed population consisted of 60% women, 28% men, and 12% children aged 13 to 16 years.

Data were collected using the KoboCollect application and included information on the source of irrigation water, the method and tools used for water collection, the various uses of the water, and the farmers' medical history.

This approach allowed for an assessment of user practices in relation to water quality and the health risks associated with the use of Tilé stream water for urban vegetable farming.

Results

Physico-Chemical quality of irrigation water for market gardening from the Tilé stream

The physico-chemical quality of irrigation water for market gardening from the Tilé stream shows notable variations (Table 1). Measured water temperatures ranged from 25.46°C to 27.49°C, exceeding the WHO guideline (10-25°C) in most neighborhoods, except at the Commercial and Tilépoulou sites. The pH varied between 5.14 and 6.63, generally below the recommended range. Overall, these results highlight relatively high temperatures and slightly acidic pH across the different sampling sites.

Table 1: Water Temperature and pH Levels in irrigation water for market gardening from the Tilé stream

Neighborhood	Parameters	Measured value	WHO Guideline	Observation
Belle-Vue	Temperature	26,40°C	10-25°C	Out of range
	pH	5,58		
Mohomou	Temperature	26,70°C	10-25°C	Out of range
	pH	6,25		
Nakoyakpala	Temperature	27,05°C	10-25°C	Out of range
	pH	6,32		
Commercial	Temperature	25,46°C	10-25°C	Within range
	pH	5,14		
Dorota	Temperature	27,15°C	10-25°C	Out of range
	pH	6,41		
Tilépoulou	Temperature	25,60°C	10-25°C	Within range
	pH	5,88		
Kwitéyapoulou	Temperature	26,33°C	10-25°C	Out of range
	pH	6,45		
Nyen	Temperature	26,92°C	10-25°C	Out of range
	pH	6,43		
Gbangana	Temperature	27,49°C	10-25°C	Out of range
	pH	6,63		
Wessoua	Temperature	26,45°C	10-25°C	Out of range
	pH	6,16		

Bacteriological and Parasitological quality of irrigation water for market gardening from the Tilé stream

The results of the bacteriological and parasitological quality of irrigation water from the Tilé stream (table 2) show significant variability across neighborhoods. Fecal coliforms ranged from 290 to 2200 CFU/100 mL, and total coliforms from 470 to 6200 CFU/100 mL, indicating substantial bacterial contamination, particularly in the Commercial, Nakoyakpala, and Mohomou neighborhoods, where levels greatly exceed recommended thresholds for irrigation, corresponding to a very high to high health risk.

Intestinal parasites such as Ascaris, Giardia, Trichomonas, Dracunculus, as well as helminth eggs and larvae, were detected in nearly all sites, further confirming the microbiological risk of these waters. The neighborhoods of Dorota, Wessoua, Gbangana, Nyen, and Kwitéyapoulou showed a moderate health risk, with variable coliform levels and notable parasitic contamination. In contrast, Tilépoulou and Bellevue recorded the lowest coliform counts and limited parasite presence, corresponding to a low health risk.

Overall, these findings indicate that most of the water used for irrigating market gardens along the Tilé stream is microbiologically and parasitologically contaminated, posing a high potential health risk to both farmers and consumers, especially when vegetables are consumed raw.

Table 2: Microbiological Contamination and Health Risk Assessment of Tilé Stream Irrigation Water

Neighborhood	Fecal Coliforms (CFU/100 mL)	Total Coliforms (CFU/100 mL)	Main Parasites	Health Risk Level
Commercial	2200	2270	Ascaris, Giardia, Trichomonas, Dracunculus, helminth larvae	Very High– Severe Pollution
Nakoyakpala	1430	1680	Trichomonas, Giardia, Dracunculus	High – Abnormal
Mohomou	1300	1600	Trichomonas, Giardia, Ascaris eggs	High – Abnormal
Dorota	650	720	Ascaris, Trichomonas, Giardia, Dracunculus, Miracidium, helminth larvae	High (parasitic) – Acceptable
Wessoua	1230	1570	Giardia	Moderate – Abnormal
Gbangana	510	6200	Miracidium, Ascaris, Giardia	Moderate – Acceptable
Nyen	1000	1200	Trichomonas, Giardia	Moderate
Kwitéyapoulou	660	840	Dracunculus, Trichomonas, Giardia, Ascaris larvae	Moderate
Belle-vue	620	830	Ascaris eggs	Low
Tilépoulou	290	470	Giardia, Trichomonas	Low

Health perception of market gardeners and reported disease distribution

The data collected from 250 market gardeners (65 men, 99 women, and 86 children) reveal a notable presence of various health conditions related to the quality of irrigation water and the sanitary conditions of the production sites. Figure 2 illustrates the weekly distribution of the main diseases reported by these market gardeners, highlighting significant variations across sociodemographic groups and types of illnesses, and indicating differential exposure to health risks associated with the use of Tilé stream water for crop irrigation.

Malaria was the most frequently reported infection among the surveyed market gardeners. The data indicate a particularly high prevalence in children, significantly higher than in adults over the five-week survey period, confirming their increased vulnerability, likely related to specific exposure conditions at the market gardening sites. Children also showed elevated rates of infectious diarrhea and amebiasis, particularly in weeks 3 and 4, reflecting their high susceptibility to waterborne and fecal-oral transmitted pathogens.

Women consistently presented higher proportions of bacterial dysentery, scabies, and gastritis, especially during the early and middle weeks of observation. This pattern suggests that their greater involvement in handling irrigation water, preparing vegetables, and participating in collective gardening activities increases their exposure to pathogens and unfavorable hygiene conditions. Gastritis, in particular, was almost exclusively reported by women, potentially linked to dietary habits, physical stress, and working conditions.

Men, on the other hand, exhibited slightly higher proportions of typhoid fever across the survey period, and syphilis was consistently more prevalent among men, particularly in weeks 3 and 4. These observations indicate that behavioral or social factors, such as dietary practices or specific exposure habits, may contribute to the higher vulnerability of men to these infections, independent of the environmental conditions at the gardening sites.

Overall, the data reveal distinct patterns of health vulnerability across demographic groups: children are the most affected by waterborne diseases, women are more exposed to conditions related to water handling and hygiene, and men show higher prevalence of infections linked to specific behaviors and exposure patterns.

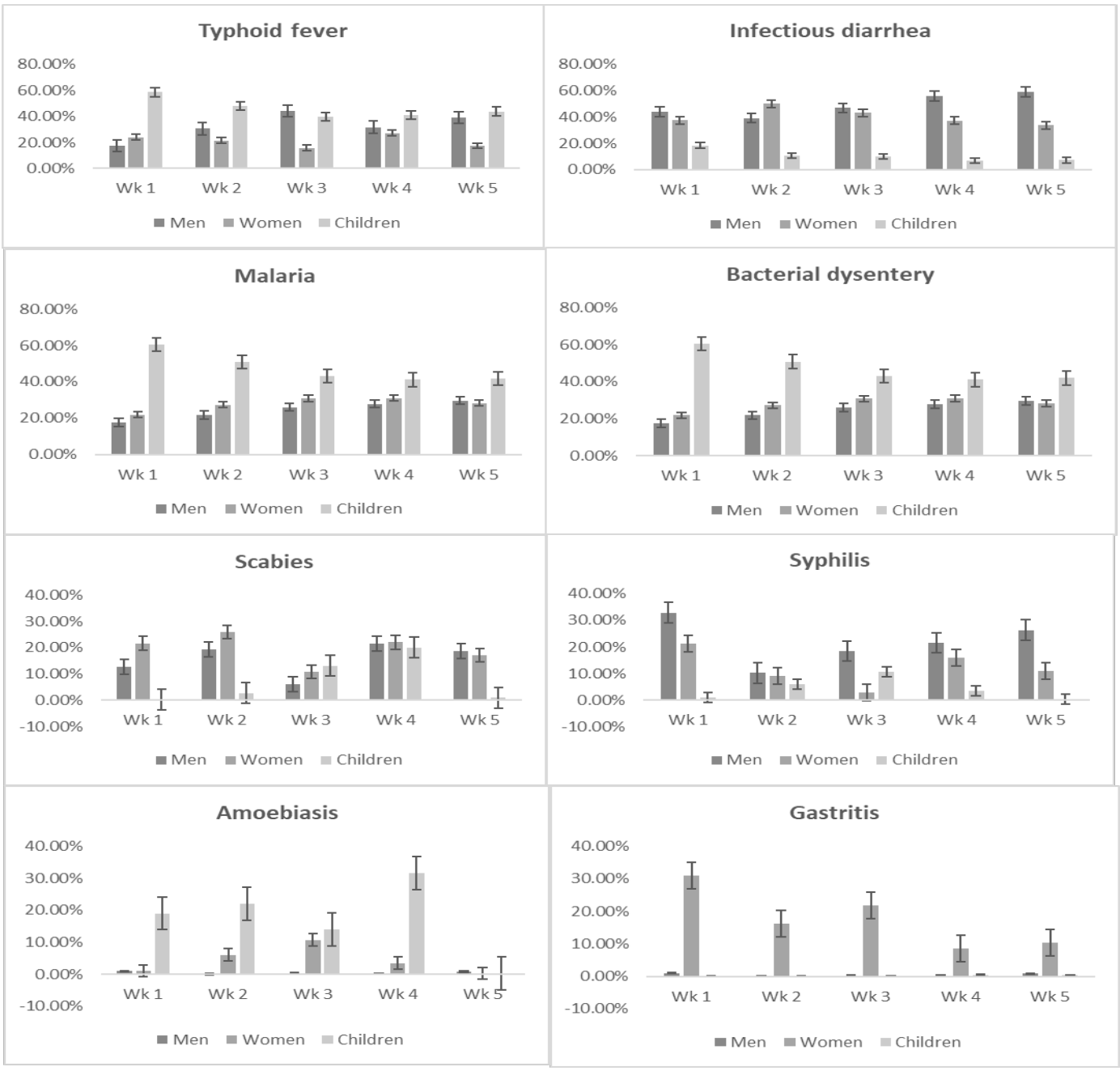

Figure 2: Distribution of reported diseases among market gardeners by Sex and Age

Discussion

In a context where wastewater is extensively used for agricultural purposes, assessing its quality is essential to determine the potential risks to human health. In this study conducted in the Urban Commune of N'Zérékoré (UCZ), physico-chemical, parasitological, and bacteriological analyses were carried out, along with surveys administered to market gardeners who are the primary users of wastewater for irrigation.

The parasitological results revealed that 60.42% of respondents suffered from malaria, with the highest prevalence observed among children aged 12 to 16 years. The high occurrence of malaria may be attributed to several environmental and sanitary factors, including poor water quality, inadequate solid waste management, lack of riverbed dredging, stagnant water puddles, and the proliferation of mosquito breeding sites. These findings are in line with those of Diallo (2012), who also reported that 59% of the surveyed population suffered from malaria-related pathologies under similar environmental conditions.

Beyond malaria, 26.39% of respondents reported syphilis, highlighting the coexistence of both water-related and sexually transmitted infections within the community. This suggests that health vulnerabilities among market gardeners are multidimensional and influenced not only by environmental exposure but also by behavioral and socio-economic factors.

Regarding typhoid fever, 28 individuals were affected, among whom 58.89% were men. This higher male susceptibility has also been reported by other studies. For example, Koffi *et al.* (2018) observed that men are generally more exposed to typhoid and other enteric infections due to their greater involvement in activities requiring direct contact with contaminated water sources, as well as the more frequent consumption of untreated water during field work. Similarly, Mansur*et al.* (2025) observed a higher prevalence of typhoid fever among men, which they attribute to increased occupational exposure and poor water hygiene.

The prevalence of diarrheal diseases, dysentery, and amoebiasis observed in this study also aligns with previous findings from regions where untreated wastewater is used for vegetable irrigation. For example, Keraita *et al.* (2008) demonstrated that irrigation using wastewater significantly increases exposure to fecal pathogens, particularly among women and children who are often involved in washing, sorting, and handling vegetables. The patterns identified in the current study (in which women exhibit higher levels of bacterial dysentery and skin infections) are consistent with these earlier observations. Likewise, Amoah *et al.* (2011) demonstrated that the use of polluted irrigation water significantly increases exposure to enteric pathogens, contributing to infections such as typhoid fever, amoebiasis, and bacterial dysentery. In India, Gupta *et al.* (2010) highlighted a high prevalence of helminthic infections among farmers using untreated wastewater, reinforcing the link between water quality and health outcomes.

Taken together, the results underscore the substantial health risks faced by market gardeners who rely on untreated wastewater for irrigation. The situation is exacerbated by environmental, occupational, and behavioral factors, as well as by insufficient sanitation infrastructure. The findings reaffirm conclusions reached by authors such as WHO (2006) and Jiménez and Asano (2008), who emphasized that wastewater reuse in agriculture, when unmanaged, can lead to significant public health concerns, particularly in low-income urban and peri-urban settings.

Conclusion

In this study, we assessed the health risks associated with the use of irrigation water for market gardening, aiming to understand its impacts on human health. The results revealed the prevalence of various diseases among market gardeners exposed to untreated water from the

Tilé stream. The use of these untreated waters for irrigation clearly exposes farmers to bacterial, parasitic, and viral infections.

Our data indicate that 58.89% of men suffered from typhoid fever, 31.52% of children were affected by amoebiasis (with 22.08% in week 2), and 25.99% of women were affected by scabies. Syphilis affected 26.39% of men, 21.16% of women, and 10.70% of children. Infectious diarrhea was reported in 48.05% of children, while bacterial dysentery affected approximately 50% of women.

These findings highlight the age- and sex-specific vulnerability to waterborne diseases and underscore the public health risks associated with the use of untreated irrigation water. They also emphasize the need for further research to better understand contamination pathways, evaluate the effectiveness of preventive measures, and develop appropriate mitigation strategies to protect both the health of market gardeners and consumers.

Author Contributions

The first author collected, processed, and drafted this article. The other authors contributed to the writing of this article.

Data Availability Statement

Data are contained within the article.

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Conflicts of Interest

The authors declare no conflict of interest.

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