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Parasitic Contamination of Irrigation Water, Soils and Vegetables Grown around Koza and Sabke Dams in Mai'adua Local Government Area, Katsina State, Nigeria

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Abstract

Vegetables are vital to human nutrition, but they can sometimes harbor pathogens, posing a threat to the consuming populace. This study assessed the parasitic contamination in irrigation water, farm soil, and vegetables in Mai'adua Local Government Area, Katsina State, Nigeria. A total of 840 samples (comprising 120 water, 120 soil, and 600 vegetable samples) were collected from Sabke and Koza irrigation sites during both the wet and dry seasons and examined for parasites using the sedimentation method. The results showed that water contamination rates were 46.6% and 45.0% during the wet and dry seasons, respectively, while the soil showed contamination rates of 53.3% and 48.3% in the wet and dry seasons, respectively. Furthermore, vegetable contamination rates were 16.0% in the wet season and 18.7% in the dry season at Sabke, while at Koza, they were 18.0% in the wet season and 16.0% in the dry season, respectively. Among the parasites isolated, Entamoeba histolytica *was the most frequent in water, with rates of 22.1% in the wet season and 22.9% in the dry season, respectively.* Ascaris lumbricoides *was widely distributed in soil (36.0% in wet and 42.9% in dry seasons, respectively). In vegetable samples, Ascaris lumbricoides also had the highest incidence (28.7% in the wet and 24.6% in the dry seasons). The overall contamination rates were 45.83% for water, 50.83% for soil, and 17.17% for vegetables. Spinach was the most contaminated (25.8%), followed by lettuce (23.3%), cabbage and pepper (14.7% each), and tomato (8.3%). The chi-square (x^2) test results indicated a significant ($P < 0.05$) difference between contamination and vegetable types. This study underscores the importance of farmers' education on hygiene practices and the use of clean water for irrigation and consumption.*

Keywords: contamination, farm soil, irrigation sites, katsina, parasites, vegetables.

INTRODUCTION

Vegetables are commonly recognized as the fresh, edible portions of herbaceous plant roots, stems, leaves, or fruits, which can be consumed either raw or upon processing through various ways (Kaparapu *et al.*, 2020). Raw vegetables are rich in vitamins, dietary fibers, and minerals, and are associated with a decreased risk of non-communicable diseases such as cardiovascular issues, stroke, and certain cancers. Some vegetables, when consumed raw in salads, retain their natural taste and preserve heat-labile nutrients (Thakur & Sharma, 2018).

However, it is crucial to note that the consumption of raw vegetables without proper washing poses a significant risk of transmitting parasitic diseases, including protozoan cysts and oocysts, as well as helminth eggs (Yahaya & Bishop, 2022). Outbreaks related to the consumption of raw fruits and vegetables have been on the rise globally, possibly influenced by changes in agricultural practices, increased consumption, and challenges in sanitization effectiveness (Dada *et al.*, 2015).

Parasite organisms that have adapted to live in or on different species represent a persistent global health concern (Loker & Hofkin, 2022). Infections caused by parasites, predominantly helminths and protozoans, particularly impact the well-being of children in impoverished communities in developing countries due to their underdeveloped immune systems (El-Sayed & Ramadan, 2017). The clinical consequences of these infections include symptoms such as malabsorption, diarrhea, blood loss, impaired work capacity, and stunted growth in affected individuals.

The epidemiological assessment of parasitic infections primarily focuses on estimating prevalence, as the clinical outcomes are generally mild (Torgerson *et al.*, 2015).

Parasites play a significant role in foodborne and waterborne diseases, and their transmission can occur through various routes, including zoonotic (from animals to humans), human-to-human, and through contaminated food and water (Ngele *et al.*, 2017). Intestinal parasitic infections are particularly prevalent in developing countries where water and sanitation facilities are inadequate (Fessehaye *et al.*, 2022). Vegetables, especially when consumed raw, serve as a significant means of transmission for intestinal parasites and contribute to foodborne outbreaks in developing nations (Auta *et al.*, 2017).

Despite their importance in a balanced diet and human health, vegetables can become contaminated by parasites like *Ascaris lumbricoides, Trichuris trichiura*, and hookworms, posing health risks to individuals (Yusuf *et al.*, 2017). Contamination sources include untreated human waste, unsafe water for irrigation, and various stages of production, transportation, storage, and commercialization (Ismail, 2016). Cultivation conditions, such as irrigation water quality, fertilizer type, and animal husbandry practices, also contribute to the risk of contamination (Fessehaye *et al.*, 2022). Consuming unwashed vegetables, particularly those cultivated in unsanitary environments, increases the likelihood of parasitic infections among the population (Osafo *et al.*, 2022).

There have been reports of parasitic infestations on vegetables in various studies in Nigeria (Auta et al., 2017; Nuhu et al., 2021; Ngele et al., 2017; Nasiru et al., 2021; Ola-Fadunsin et al., 2022). However, in certain regions of northern Nigeria, where irrigation with dam water is commonly practiced for vegetable cultivation, there is a scarcity of data concerning the contamination of vegetables with parasites related to Koza and Sabke, specifically in the Mai'adua Local Government Area. Similarly, it is common knowledge that local farmers often package and sell these vegetables under unhygienic conditions.

It is necessary to ascertain this, given that vegetables cultivated in irrigation zones are susceptible to parasite infestation. This study adds knowledge by establishing a direct link between environmental contamination and food safety risk in a semi-arid, rural Nigerian setting. Therefore, the study aimed to evaluate the contamination levels of soil, water, and vegetables grown around Koza and Sabke dams during both the wet and dry seasons, and to assess the public health impact of parasites found on vegetables commonly grown in Mai'adua.

MATERIALS AND METHODS

Study area

The study was carried out in Mai'adua, spanning a total area of 528 km² around Koza, located at 13°11'66"N latitude and 8°31'05"E longitude. While Sabke is situated at 13°03'12"N latitude and 8°16'19"E longitude, it covers the dams. Katsina State, Nigeria. The study involved seasonal sampling during the wet and dry periods, conducted between August 2023 to February 2024. Mai'adua, a local government area with a projected population of 360,700 as of 2022 (NPC & NBS, 2022). Mai'adua shares a border with the Republic of Niger, as well as the Daura, Dutsi, and Mashi local government areas. Koza and Sabke are key irrigation zones, contributing significantly to vegetable production for local markets and consumption. Mai'adua is also home to a large historical urban and rural market held on Sundays, which serves as an international trading hub between Nigeria and Niger. Livestock, including cattle, sheep, goats, camels, donkeys, and horses, as well as grains such as maize, sorghum, millet, and soybeans, are commonly traded. Mai'adua has a semi-arid climate, characterized by an average annual temperature of 37°C, 653 mm of rainfall, and a relative humidity of 30% (Usman, 2018).

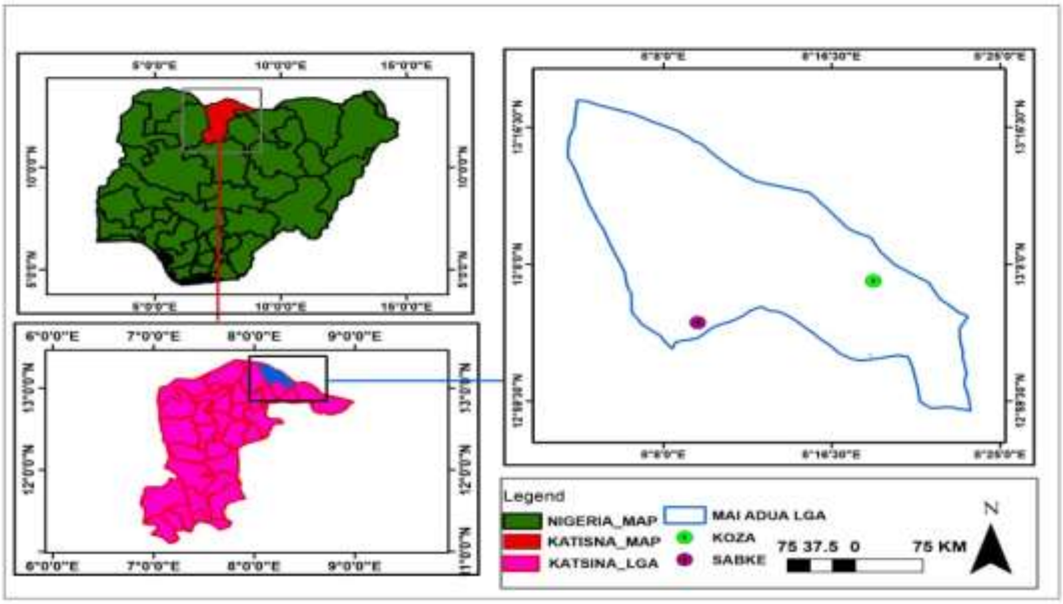

Figure 1: Map showing the study areas
Source: National Aeronautic and Space Administration Spot Image 2025.

Sample Collection
Samples of vegetables (lettuce, cabbage, spinach, tomato, and pepper), farm soil and irrigation water were collected during both seasons. Each vegetable and farm soil sample was put in a separate nylon bag. The irrigation water samples from the farms in the study areas were collected aseptically in sterile, covered bottles labeled with an identification number and the date of collection, and then brought to the Biology Laboratory at Umaru Musa Yar'adua University, Katsina. A total of 600 vegetable samples were collected, along with 120 samples each of farm soil and irrigation water for this research.

Soil examination
Soil samples (2g each) were taken from several locations around the Koza and Sabke dams. At each sampling site, soil samples were taken at depths of 1 to 2 cm, manually ground into fine granules, and then dried in air. They were filtered through a sieve, and then the soil was combined with a Tween 20 solution in a vortex shaker. The mixture was centrifuged, and then the supernatant was removed using a dropper. The sediment, which had been thoroughly mixed in a vortex shaker, was then treated with a sucrose solution. The mixture was centrifuged for five minutes. The solution was kept in the tube for an hour without being touched, and then placed under a microscope for examination (Khurana *et al.*, 2021).

Irrigation water examination
The irrigation site water was collected in sterilized 60 mL plastic bottles with labels. The samples were brought to the lab while being stored on ice. To eliminate waste and big particles, the water was filtered through a clean sieve. It was centrifuged, after which the supernatant was removed, and the sediment was carefully dropped on a clean glass slide with iodine. The samples were checked for the presence of parasite stages under a light microscope,, following the descriptions provided by Cheesbrough (2017).

Vegetable examination
One hundred grams (100g) of each vegetable sample was cut into smaller pieces and placed into a clean beaker containing physiological saline (NaCl) to wash the samples. After removing fragments from the washing saline using clean forceps, the solution was left undisturbed for 24 hours to allow sedimentation to occur. After sedimentation, the top layer of the washing saline was discarded, leaving the sediment, and then centrifuged for 5 minutes. The supernatant was removed, and the remaining material was placed on a glass slide, stained with Lugol's iodine solution, and then inspected under a microscope (Abougrain *et al.*, 2010).

Statistical analysis
Statistical analysis was performed using GraphPad Prism statistical software (version 3.01). The frequencies of the parasite were determined using descriptive statistics. Chi-square (x^2) was used to determine whether there is any significant difference between parasites and contamination of different water, soil, and vegetable samples, as well as differences in location of sampling sites and between seasons, at a statistical significance of $P < 0.05$.

RESULTS

The prevalence of parasitic contamination in water samples during both the wet and dry seasons is shown in Table 1, with 46.6% of samples contaminated during the wet season and 45.0% during the dry season. There was no significant difference (χ^2=*1.140, P=0.951*) between the study areas during both the wet and dry seasons.

Table 1: Prevalence of parasitic contamination of water samples during wet and dry seasons from selected irrigated farms/sites

Site	Wet Season		Dry Season			
	No. of samples examined	No. of samples contaminated (%)	No. of samples examined	No. of samples contaminated (%)	χ^2	*P*-value
Sabke	30	11(36.6)	30	15(50.0)	*1.140*	*0.951*
Koza	30	17(56.6)	30	12(40.0)		
Total	**60**	**28(46.6)**	**60**	**27(45.0)**		

The prevalence of parasite contamination in soil samples during the dry and wet seasons is shown in Table 2. The degree of contamination in the wet season is 53.3%, whereas in the dry season it is 48.3%. There was no significant difference (χ^2=*1.517, P=0.911*) between the study areas during both the wet and dry seasons.

Table 2: Prevalence of parasitic contamination of soil samples during wet and dry seasons from selected irrigated farms/sites

Site	Wet Season		Dry Season			
	No. of samples examined	No. of samples contaminated (%)	No. of samples examined	No. of samples contaminated (%)	χ^2	*P*-value
Sabke	30	19(63.3)	30	12(40.0)	*1.517*	*0.911*
Koza	30	13(43.3)	30	17(56.6)		
Total	**60**	**32(53.3)**	**60**	**29(43.8)**		

The prevalence of parasitic contamination in vegetables is shown in Table 3. Out of the collected samples, the contamination rates were 16.0% in the wet season and 18.7% in the dry season at Sabke, while in Koza, the rates were 18.0% and 16.0% in the wet and dry seasons, respectively. The statistics show no significant difference between the two seasons and the various vegetable types.

The identity of parasites isolated from water samples throughout the wet and dry seasons is shown in Table 4, where Entamoeba histolytica has the highest frequency of occurrence, with 22.1% in the wet and 22.9% in the dry season, followed by Ascaris lumbricoides with 17.6% and 18.6% in the wet and dry seasons, respectively. *Balantidum coli, Cryptosporidium parvum, Giardia lamblia, Schistosoma mansoni, Enterobius vermicularis, Strongyloides stercoralis* were also found to be present.

Similarly, the identity of parasite species found in soil samples collected from selected irrigation farms throughout wet and dry seasons are shown in Table 4, where *Ascaris lumbricoides* was found to be widely distributed (36.0% in the wet season and 42.9% in the dry season), followed by *Trichuris trichiura* (22.0% in the wet season and 24.4% in the dry season). *Hookworm, Strongyloides stercoralis, Enterobius vermiciularis,* and *Taenia spp.* were also present.

Furthermore, the identity of parasite species isolated from vegetables in the wet and dry seasons is shown in Table 4, with *Ascaris lumbricoides* having the highest incidence at 28.7% in the wet season and 24.6% in the dry season, followed by *Enterobius vermicularis* at 12.2% and 14.5% in both seasons. *Entamoeba histolytica, Giardia lamblia, Hookworm, Strongyloides stercoralis, Taenia spp., Trichuris trichiura,* and *Faciola spp.* were all found.

Table 3: Prevalence of parasitic contamination of cultivated vegetables during wet and dry seasons in the study sites

Site	Seasons	Vegetables	No. of Samples Examined	No. of Samples Contaminated (%)	χ^2	*P*-value
Sabke	Wet	Pepper	30	2(6.6)	*5.339*	*0.376*
		Tomato	30	4(13.3)		
		Lettuce	30	6(20.0)		
		Cabbage	30	3(10.0)		
		Spinach	30	9(30.0)		
		Total	**150**	**24(16.0)**		
	Dry	Pepper	30	4(13.3)	*4.173*	*0.525*
		Tomato	30	3(10.0)		
		Lettuce	30	10(33.3)		
		Cabbage	30	5(16.6)		
		Spinach	30	6(20.0)		
		Total	**150**	**28(18.7)**		
		Sub Total	**300**	**52(17.33)**		
Koza	Wet	Pepper	30	5(16.6)	*4.583*	*0.469*
		Tomato	30	2(6.6)		
		Lettuce	30	7(23.3)		
		Cabbage	30	4(13.3)		
		Spinach	30	9(30.0)		
		Total	**150**	**27(18.0)**		
	Dry	Pepper	30	6(20.0)	*3.993*	*0.550*
		Tomato	30	1(3.3)		
		Lettuce	30	5(16.6)		
		Cabbage	30	5(16.6)		
		Spinach	30	7(23.3)		
		Total	**150**	**24(16.0)**		
		Sub Total	**300**	**51(17.00)**		
		Grand Total	**600**	**103(17.17)**		

Table 4: Identity of Parasite Species Recovered from Water, Soil, and Vegetable Samples during Wet and Dry Seasons and their frequencies from the study sites

Parasite Species	Water		Soil		Vegetable	
	Wet (%)	Dry (%)	Wet (%)	Dry (%)	Wet (%)	Dry (%)
Ascaris lumbricoides	12(17.6)	9(18.6)	18(36.0)	21(42.9)	19(28.7)	17(24.6)
Balantidium coli	5(7.4)	0(0.0)	-	-	-	-
Cryptosporidium parvum	9(13.2)	7(14.6)	-	-	-	-
Enterobius vermicularis	8(11.7)	4(8.3)	2(4.0)	1(2.0)	8(12.1)	10(14.5)
Entamoeba histolytica	15(22.1)	11(22.9)	-	-	8(12.1)	9(13.0)
Giardia lamblia	10(14.7)	10(20.8)	-	-	7(10.6)	4(5.8)
Hookworm	-	-	6(12.0)	9(18.3)	8(12.1)	10(14.5)
Schistosoma mansoni	2(2.9)	1(2.1)	-	-	-	-
Strongyloides stercoralis	7(10.3)	6(12.5)	8(16.0)	3(6.1)	5(7.6)	11(15.9)
Taenia spp.	-	-	5(10.0)	3(6.1)	2(3.0)	1(1.4)
Trichuris trichiura	-	-	11(22.0)	12(24.5)	4(6.0)	5(7.2)
Faciola spp.	-	-	-	-	5(7.6)	2(2.8)
Total	68(99.9)	48(99.8)	50(100)	49(99.9)	66(99.8)	69(100)

The study's findings on the prevalence of parasites in vegetables from selected irrigation farms in Mai'adua are presented in Table 5. Spinach had the highest contamination rate at 25.8%, followed by lettuce at 23.3%, while cabbage and pepper both had a contamination rate of 14.7%. Tomatoes had the lowest contamination rate at 8.3%. The overall contamination rate for vegetables was 17.17%. There was a significant association (χ^2=12.465, *P*=0.029) between the prevalence of parasite contamination and the different types of vegetables.

Table 5: Prevalence of parasites in vegetables from the selected irrigation farms

Vegetables	No. of samples examined	No. of samples contaminated (%)	χ^2	*P*-value
Pepper	120	17(14.7)	*12.465*	*0.029*
Tomato	120	10(8.3)		
Lettuce	120	28(23.3)		
Cabbage	120	17(14.7)		
Spinach	120	31(25.8)		
Total	**600**	**103(17.17)**		

The study's findings on parasite distribution in vegetables, water, and soil are detailed in Table 6. Vegetables were most commonly contaminated with *Ascaris lumbricoides* (28.9%) and least with *Taenia spp*. (2.2%), along with other parasites, such as *Entamoeba histolytica*, *Giardia lamblia*, and Hookworm. There was no significant difference (χ^2=35.643, *P*=0.839) in parasite types across different vegetables. In water, *Entamoeba histolytica* had the highest contamination rate (22.4%), while *Schistosoma mansoni* had the lowest (2.6%). Soil samples showed *Ascaris lumbricoides* as the most prevalent (39.4%), followed by *Trichuris trichiura* (23.2%) and Hookworm (15.2%).

Table 6: Distribution of parasites recovered from vegetables, water and soils for the entire study period and their percentages

Parasites tified	Pepper	Tomato	Lettuce	Cabbage	Spinach	Total	Water	Soil
Ascaris lumbricoide	4(23.5)	6(42.9)	6(18.2)	6(24.0)	14(30.4)	36(28.9)	21(18.1)	39(39.4)
Entamoeba histolytica	1(5.9)	0(0.00)	5(15.2)	4(16.0)	7(15.2)	17(12.6)	26(22.4)	ND
Enterobius vermicularis	4(23.5)	1(7.1)	4(12.2)	6(24.0)	3(6.5)	18(13.3)	12(10.3)	3(3.0)
Giardia lamblia	2(11.8)	0(0.00)	3(9.1)	1(4.0)	5(10.9)	11(8.1)	20(17.2)	ND
Hookworm	2(11.8)	1(7.1)	6(18.2)	4(16.0)	5(10.9)	18(13.3)	ND	15(15.2)
Strogyloides stercoralis	1(5.9)	3(21.4)	4(12.2)	3(12.0)	5(10.9)	16(11.9)	13(11.2)	11(11.1)
Taenia spp.	1(5.9)	2(14.3)	0(0.00)	0(0.00)	0(0.00)	3(2.2)	ND	8(8.1)
Trichuris trichiura	2(11.8)	0(0.00)	2(6.1)	0(0.00)	5(10.9)	9(6.6)	ND	23(23.2)
Faciola Spp	0(0.00)	1(7.1)	3(9.1)	1(4.0)	2(4.3)	7(5.2)	ND	ND
Balantidium coli	ND	ND	ND	ND	ND	ND	5(4.3)	ND
Cryptosporidium	ND	ND	ND	ND	ND	ND	16(13.8)	ND
Schistosoma mansoni	ND	ND	ND	ND	ND	ND	3(2.6)	ND
Total	**17(99.9)**	**14(99.9)**	**33(99.9)**	**25(100)**	**46(99.9)**	**135(100)**	**116(99.9)**	**99(99.9)**
χ^2=35.643, P=0.839.								

ND= Not detected

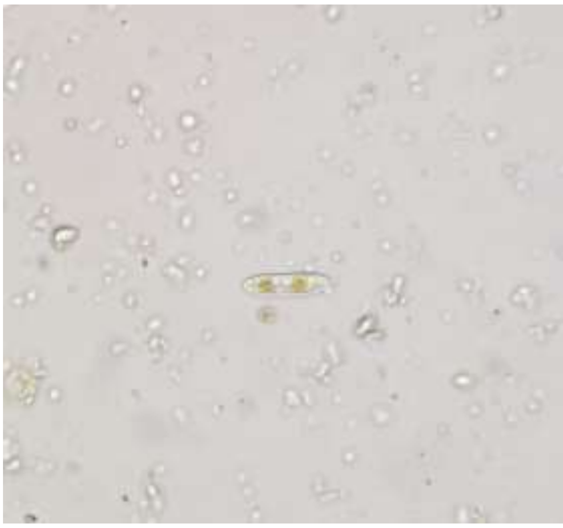

Figure 2: ***E. vermicularis*** **egg (40X)**

Figure 3: ***S. stercoralis*** **larva (40X)**

Figure 4: ***A. lumbricoides*** **egg (40X)**

Figure 5: ***E. histolytica*** **(40X)**

DISCUSSION

The presence of some parasites in water, soil, and vegetable samples in the present study may be as a result of contamination of water sources by human activities around the dams. These activities include open defaecation by the farmers and other animals. Among 120 water samples analyzed, a prevalence of 45.83% for parasite contamination in irrigation water was observed in Mai'adua. The results of this study align with similar studies, such as Abdullahi et al. (2018) in the Dutsinma local government area of Katsina State. Oyibo *et al*. (2016) in Kogi, and Ola-Fadunsin *et al*. (2022) in Kwara reported lower rates of 63.3%, 91.3%, and 52.9%, respectively, which are higher than the 28.1% recorded by Ani & Itiba (2015). The most prevalent parasite found across seasons was *Entamoeba histolytica*, indicating a risk of infection in the vegetables of the area, which poses a significant public health concern as it can cause amoebiasis, leading to diarrhea, dysentery, and potentially life-threatening liver abscesses, especially in populations with poor sanitation and limited access to clean water. This finding aligns with previous studies by Abdullahi et al. (2018) and Mohammed *et al.* (2016), which also highlighted a high prevalence of *E. histolytica*. This parasite is mostly prevalent due to contaminated water sources, poor sanitation, fecal-oral transmission, warm and humid environments, and inadequate water treatment (Angelici & Karanis, 2019). The significant level of water contamination with parasites is attributed to pollution from human and animal feces, as observed during field visits where indiscriminate defecation directly into vegetable farms was noted. Open defeacation and improper waste disposal were found to impact irrigation water quality, with runoff from fecal sites entering the main river channel.

Animal rearers were also reported to be using the dams to provide water for their livestock, particularly cattle. Animal droppings along the banks of the dams also contributed to parasitic contamination in the dams (Douti *et al*., 2021).

The results from the current study showed that soil samples had a prevalence of 50.83% parasitic contamination. This finding is consistent with rates reported in some previous similar studies by Kafle et al. (2014) in Bhaktapur, Fessehaye et al. (2022) in Eritrea, Noellie et al. (2015) in Burkina Faso, and Ja'afaru et al. (2020) in Adamawa. Helminths were identified as the predominant parasites in soil-cultivated vegetable fields irrigated from the Sabke and Koza dams. *Ascaris lumbricoides* was the most prevalent parasite, at 39.4%, consistent with the findings of Goodhead et al. (2022) and Nwoke *et al*. (2015). The abundance of *Ascaris lumbricoides* in soil is influenced by soil chemical composition and favorable ecological conditions. Moisture content also play a role in its survival. Soil chemical composition factors such as pH, organic matter, and nutrient availability affect the survival of *Ascaris* eggs in the soil. *Ascaris* eggs prefer rich organic matter (Osman, 2013). Adequate moisture is crucial for their survival, as desiccation can reduce viability, while waterlogged conditions may also impact their abundance. Various intestinal parasites, such as *Trichuris trichiura*, Hookworms, Strongyloides stercoralis, Enterobius vermicularis, and Taenia species, were found in the soil of vegetable fields. This emphasizes that vegetables harvested from these farms should be properly washed before cooking and are unlikely to be eaten raw.

This study revealed an overall prevalence of 17.17% in selected vegetable fields in Mai'adua, lower than 26.0%, 37.4%, 28.3%, and 41.6% reported by (Yahaya and Bishop 2022; Okunlola 2020; Ngele *et al*. 2017; Auta and Bawa 2017), respectively. However, this is greater than the 3.5% and 8.67% reported by Adamu *et al*. (2012), and Odihi *et al*. (2022), respectively. The variance in total parasite prevalence observed in these studies may result from variations in the quantity and types of vegetables collected in different geographic locations, as well as the farming and trading activities of the farmers and traders from whom the vegetables are gathered. Other possible causes include the manner in which vegetables were collected, the time of the season they were collected, and the type of soil and irrigation water used in vegetable farming. The study examined lettuce, cabbage, spinach, tomatoes, peppers, and tomatoes. In this study, spinach had the highest prevalence rate of 25.8%, while tomatoes had the lowest prevalence rate of 8.3%. High contamination of spinach may be due to its large surface area and hairy nature. These may harbor large quantities of eggs. The low parasitic prevalence of tomatoes may be a result of their small surface area and the smooth nature of the fruits, which may not support the existence of eggs on them. This could be because spinach and lettuce are leafy vegetables that are close to the ground, making them susceptible to contamination by parasites during flooding and heavy rain. Our findings is in line with those of Fumilayo *et al*. (2019), and Nuhu *et al*. (2021), who found that spinach was the most contaminated and tomatoes were the least contaminated. Our study aligns with the findings of Odihi *et al*. (2022), and Al-magrin (2010), who found lettuce to be the most infested with parasites. However, a study conducted by Sounyo and Gboeloh (2021) and Bakele et al. (2017) discovered that tomatoes had the highest rate of parasite infection.

Therefore, the variations in the findings might be attributed to environmental differences, likewise irrigation sites typically have damp soil conditions that create an ideal environment for the survival and growth of parasite eggs and larvae, which can contaminate the soil through the fecal matter of infected individuals. Moreover, the presence of animals, such as livestock, in and around irrigation sites can elevate the risk of parasite transmission. Animals can serve as hosts for parasite, and their excrement can contaminate the soil, thus contributing to the higher prevalence of parasites (Jwher *et al*., 2021). The most common parasitic larvae on the vegetables collected from the two selected irrigation areas were *Ascaris lumbricoides*, accounting for 28.9% of the total, showing that the vegetables were possibly contaminated by soil from the sites. Adejumoke (2015) and Nasiru et al. (2021) reported Ascaris lumbricoides to be the most common parasite found on vegetables. Parasitic contamination of vegetables encountered in our study may have resulted from the use of contaminated water for washing or from the application of organic manures (including animal or human feces) during cultivation. All vegetable types sampled were contaminated with one or more parasites in a similar manner. There have been reports of parasitic contamination in all fruit and vegetables studied in Nigeria and other parts of the world. This means that parasite contamination of vegetables is a global issue that requires immediate attention to control it and minimize its negative effects.

CONCLUSION

In conclusion, vegetables cultivated in Mai'adua are contaminated with parasitic cysts and eggs. Vegetables, with their rough and folded leaves, tend to have more contamination. *Ascaris lumbricoides* is the most common parasite found on the produce in the study areas. Additionally, more parasites are found in the wet season compared to the dry season. There is need for proper washing and cooking of vegetables to reduce health risks. This is supported by the overall contamination rates of 45.83% in water, 50.83% in soil, and 17.17% in vegetables, with spinach (25.8%) and lettuce (23.3%) being the most contaminated. The Chi-square (x^2) test revealed a significant ($P < 0.05$) difference between contamination and vegetable types, confirming the influence of vegetable morphology and seasonal variation on parasitic prevalence.

The study suggests that environmental conditions, farming practices, and irrigation methods have a significant influence on parasite prevalence. Addressing open defecation, improving sanitation, and adopting better irrigation practices are crucial to mitigating parasitic contamination and ensuring food safety. Future studies should consider using advanced diagnostic methods such as PCR and ELISA to improve the sensitivity and specificity of parasite detection. These techniques can provide more accurate identification and better insight into the epidemiology of parasitic contamination in agricultural settings.

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