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Environmental Study to Detect Parasitic Pollution in Irrigation Water, Soil, and Selected Vegetables in the Ghat Region

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دراسة بيئية للكشف عن التلوث الطفيلي في مياه الري والتربة وبعض أنواع الخضراوات في منطقة غات

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Abstract

Parasitic pollution of irrigation water, soil, and vegetables is a significant public health and environmental concern. Parasites can transmit to humans through contaminated water or vegetables, causing serious illnesses. This problem is particularly acute in developing countries due to inadequate healthcare and water scarcity. This study aimed to assess the prevalence of parasitic pollution in irrigation water, soil, and locally produced vegetables within the Ghat region, and identify the types of parasites present. Conducted across Greater Ghat (Al-Awinat, Tahala, Ghat, Al-Fayyut, Al-Barakat, Eseen), the research unfolded in three phases: 1. Water Quality: 23 irrigation water samples were analyzed for physicochemical properties (Salinity, TDS, EC, Temperature, pH, DO, BOD) and screened for parasitic contamination.2. Soil Contamination: 46 soil samples were examined for parasitic pollution.3. Vegetable Contamination: 66 samples of leafy greens (lettuce, parsley, Al-Barakat, mint, chard) were collected from the same farms as the water and soil samples and tested. An alarming 91% (60 out of 66) of the vegetable samples tested positive for parasitic contamination. Nearly half (47%) of the contaminated vegetable samples harbored more than three parasite types, indicating statistically significant polyparasitism. 20 different parasite species were identified. Prevalence rates were: 14% in water samples, 44% in soil samples, 42% in vegetable samples. The most prevalent parasites included *Ascaris eggs*, *Amoeba spp*., *Ascaris lumbricoides*, *Ascaris worms*, *Cryptosporidium*, and *Clonorchis sinensis*. The widespread presence of these pathogens highlights a critical public health risk. practices, fostering collaboration between food safety authorities, and strengthening academic-government partnerships to monitor environmental pollution. Supporting epidemiological studies to track parasites across diverse environmental samples is vital for developing effective strategies to reduce disease transmission.

Keywords: Parasitic contamination, Physicochemical properties, Treated soil, Contaminated vegetables Parasitic spread.

الملخص

يعد التلوث الطفيلي لمياه الري والتربة والخضروات مشكلة صحية وبيئية مقلقة، إذ يمكن أن تنتقل الطفيليات إلى الإنسان عن طريق تلوث المياه أو الخضروات مسببة جملة من الامراض الخطيرة ، وتزداد هذه المشكلة خاصة في البلدان النامية بسبب تدني مستوى العناية الصحية وندرت المياه، لذلك هدفت هذه الدراسة إلي تقييم انتشار التلوث الطفيلي في مياه الري والتربة والخضراوات المنتجة في منطقة غات، ومعرفة أنواع الطفيليات المتواجدة بها حيث تمت هذه الدراسة في مناطق غات الكبرى (العوينات، تهالا، غات، الفيوت، البركت، إيسين) علي ثلاث مراحل : تمثلت المرحلة الأولي في دراسة جودة

المياه حيث جمعت 23 عينة من مياه الري لفحص الخواص الفيزوكيميائية : (Salinity)، (TDS)، (EC)، (Tem)، (PH)، (DO)، (BOD) والكشف عن التلوث الطفيلي بها ، يليها المرحلة الثانية التي تم فيها الكشف عن التلوث الطفيلي في التربة من خلال فحص 46 عينة ، أما المرحلة الأخيرة فقد تم فيها فحص 66 عينة من بعض أنواع الخضروات الورقية (الخس، البقدونس، الجرجير، النعناع، السلق) من نفس المزارع التي تم جمع عينات المياه والتربة منها وكانت نتائج 60 عينة إيجابية بنسبة 91 % ، سجلت ما نسبته 47 % من عينات الخضروات وجود أكثر من ثلاثة أنواع من الطفيليات إيجابية التعدد الطفيلي وهذا يعتبر ذات دلالة إحصائية للتلوث الطفيلي . تم اكتشاف 20 نوعا مختلفا من الطفيليات بنسبة انتشار 14% في عينات المياه و44% في عينات التربة و42% في عينات الخضار وكانت أكثر الطفيليات انتشارا *Ascaris egg* و *Amoeba spp* و *Ascaris lumbricoides* و *Ascaris worm* و *Cryptosporidium* و *Clonorchis sinensis* ومن خلال هذه النتائج نستنتج أن تفشي وانتشار المسببات المرضية في المجتمعات المختلفة أمر ذا أهمية لصياغة استراتيجيات تدخل مناسبة عبر تثقيف المزارعين حول الممارسات الزراعية الصحيحة وتوحيد الجهود بين القطاعات المعنية بالأمن الغذائي في محاولة لتقييم مستوى التلوث البيئي من خلال التعاون بين القطاع الأكاديمي والمسؤولين ودعم الدراسات الوبائية لرصد الطفيليات المختلفة من عينات بيئية متنوعة لتقليل تفشي الأمراض .

الكلمات المفتاحية: التلوث الطفيلي، الخواص الفيزيوكيميائية، التربة المعالجة، الخضروات الملوثة، الانتشار الطفيلي

Introduction:

Parasites are among the most common microorganisms affecting both humans and animals [1]. They are defined as eukaryotic organisms that possess a wide array of transmission and infiltration pathways, including water, food, and soil [2]. Although the majority of these parasites do not reproduce in food products (3), their high resilience to sudden environmental changes and rapid transmission rates makes parasitic infections particularly dangerous compared to other infectious diseases [4]. More than two billion people worldwide, approximately a quarter of the global population, are infected with protozoan and helminth parasites, making them among the most widespread infectious diseases, particularly among children in low-income and developing countries [5,6].

The level of parasitic contamination in any given area can be influenced by several factors that determine the nature of transmission. These factors may include, but are not limited to, environmental conditions, habitat, and life cycles of the parasites [7]. Contamination may also result from direct or indirect exposure to polluted substances, such as the use of contaminated irrigation water [8], untreated organic fertilizers، or fecal pollution. These elements serve as effective means for transmitting infectious stages like eggs، larvae، and cysts، which are responsible for causing infections [9].

Water plays a pivotal role in agricultural production, as it is essential for maintaining food security [10]. Thus, assessing the quality of water used for various irrigation purposes is critically important to ensure consumer health (3). Irrigation water is considered a primary source of infection by microorganisms at various stages of their life cycles, due to its capacity to harbor large reservoirs of foodborne pathogens [11]. The use of contaminated irrigation water directly impacts the microbiological quality of crops, especially fresh produce [12]. Numerous studies have reported that a significant number of consumers are at risk due to the consumption of crops irrigated with unsafe water [10] or those exposed to biological contaminants such as bacteria, protozoa, helminths, and viruses, most of which are present in irrigation water as a result of surface runoff contamination with feces, leakage from animal feeding facilities, or the mixing of wastewater with irrigation sources [13,14].

Over 1.45 billion people are affected globally, and approximately 819 million individuals are infected by soil-transmitted helminths (15). Agricultural soils can become contaminated due to improper practices such as the use of untreated organic fertilizers, irrigation with inadequately treated wastewater, or the direct disposal of feces from infected hosts into the soil [16]. Therefore, parasitic contamination through soil does not solely depend on environmental and regional conditions, but rather on the extent to which economic and social development standards are implemented or neglected [17].

Given this reality, there is growing global concern over the safety of food products, especially in the absence of proper sanitary management and safe agricultural practices. This necessitates ongoing monitoring of ready-to-eat foods, particularly raw vegetables [13]. In recent years, numerous epidemiological reports from various parts of the world have indicated that the increase in foodborne illnesses is directly linked to the consumption of raw vegetables, in both developing and developed nations, due to various hygiene shortcomings [12,10].

Although vegetables are rich in fibers, proteins, vitamins, and minerals, and incorporating them into the diet is essential for healthy nutrition and for providing the body with vital benefits [13,18]. if consumed unclean, they can pose significant risks to public health. Contaminated vegetables can serve as important vectors for transmitting both the immature and mature stages of various parasites [19,20]. Parasitic contamination of vegetables and fresh produce can occur at different stages, including growth, harvest, post-harvest handling, and distribution [21].

One of the primary indicators of non-compliance with good agricultural practices is the presence of these parasites in food products, especially in leafy vegetables that are consumed raw [18]. Accordingly, the present study aims to assess the prevalence of parasitic contamination in irrigation water, soil, and vegetables produced in the Ghat region. To the best of our knowledge, there are no previously published data on this specific issue, making this study the first of its kind in the area. Its objective is to delineate the extent of contamination and support relevant authorities in taking necessary actions to protect consumer health and enhance public well-being by improving food quality. In this context, the importance of this study lies in the utilization of its findings to help reduce existing contamination through the implementation of appropriate policies and sound agricultural practices.

Materials and Methods

Study area:

This study was conducted between February and May in the Greater Ghat region, which includes the areas of Al-Awinat, Tahala, Ghat, Al-Fayyut, Al-Barakat, and Eseen. Samples were collected from irrigation water, soil, and various types of vegetables from several farms supplying produce to the region. Specifically, the sources included 3 farms in Al-Awinat, 1 farm in Tahala, 5 farms in Ghat, 5 farms in Al-Fayyut, 7 farms in Al-Barakat, and 3 farms in Eseen.

Sample Collection:

The study was carried out in three stages:

Stage One: Irrigation Water Samples

A total of 23 samples of irrigation water used for watering crops were collected from the targeted farms. Each sample, approximately 0.5 liters, was placed in plastic bottles thoroughly rinsed with distilled water. Samples were stored at 4°C during transport to the Biology Department Laboratory to carry out preliminary physicochemical analyses. These were conducted using the HANNA HI 5421 (pH meter) and HANNA HI 15522 devices, measuring parameters such as salinity, total dissolved solids (TDS), electrical conductivity (EC), temperature (Tem), pH level, dissolved oxygen (DO), and biological oxygen demand (BOD).

For parasitological examination during this stage, the water samples were first filtered using filter paper placed in clean containers and left to settle for 12 hours. The sediment was carefully transferred to centrifuge tubes and centrifuged at 3800 rpm for 15 minutes. The resulting sediment was mixed with 9 ml of a solution containing formalin and diethyl ether, then centrifuged again under the same conditions to obtain additional sediment. A drop of iodine stain was added to the sediment, and microscope slides were prepared by placing a small smear at the center of a clean slide, gently covering it with a coverslip to avoid air bubbles, and allowing it to dry for several minutes for accurate results. The slides were then examined under a microscope at magnifications of 10X and 40X to detect the presence of various types of parasites.

Stage Two: Soil Samples

In this stage, 46 soil samples were collected using clean, tightly sealed containers. The samples were kept cool during transport to the laboratory. From each sample, 50 ml of soil was mixed with 30 ml of glycine-MI solution and homogenized for 30 minutes. The mixture was left to settle for 5 to 10 minutes, after which the upper sediment was transferred into centrifuge tubes and spun at 3800 rpm for 15 minutes. The resulting final sediment was divided into new tubes, where 9 ml of formalin and diethyl ether were added in equal parts, mixed thoroughly, and centrifuged again at the same speed for 15 minutes. The sediment was then stained with Giemsa stain and modified Ziehl-Neelsen stain. After staining, the slides were fixed with methanol and examined under a light microscope using a 100X oil immersion objective.

Stage Three: Vegetable Samples

A total of 66 samples of leafy vegetables, including lettuce, parsley, Al-Barakat, mint, and Swiss chard, were collected from the same farms used for water and soil sampling. Between 2 to 3 samples were collected from each farm, placed in clean, sealed plastic bags, labeled with the corresponding farm names and codes, and kept under refrigeration until transported to the lab. The vegetables were cut into small pieces and soaked in a physiological saline solution (0.85% sodium chloride), then left to settle for 24 hours. The upper sediment was transferred into centrifuge tubes and spun at 3800 rpm for 15 minutes. After removing the supernatant, the remaining sediment was collected and examined using Giemsa and modified Ziehl-Neelsen stains [3,14,18,22,23,24,25,26].

Statistical Analysis:

The Statistical Package for the Social Sciences (SPSS), version 27.0, was used to test the statistical relationship between the variables under study. Descriptive statistics were employed to summarize frequencies, prevalence rates, parasite distribution, and contamination levels. The Chi-square test was used to determine the significance of differences in the prevalence and distribution of parasites in soil and various vegetable samples. A significance level of less than 0.05 was considered statistically significant.

Results:

A total of 135 samples were examined in this study to detect parasitic contamination in irrigation water, soil, and vegetables. Table (1) shows the prevalence of parasites in these sample types, where 20 different parasite species were identified. The prevalence rates were 14% in water samples, 44% in soil samples, and 42% in vegetable samples. Soil samples recorded the highest contamination rate, followed by vegetables, while water samples showed the lowest parasitic contamination rate.

Table (1): Prevalence of parasitic contamination among water soil and vegetable

Parasites	Sample type		
	Waters	Soil	Vegetables
	No(%)	(%) No	No(%)
Ascaris worm	(87) 20	(26) 12	(35) 24
Ascaris egg	(48) 11	(91) 42	(53) 36
Ascaris lumbricoides	(22) 5	(65) 30	(31) 21
Amoeba spp	(87) 20	(83) 38	(82) 56
Clonorchis sinensis	(26) 6	(78) 36	(32) 22
Coccidisis spp	(0) 0	(7) 3	(15) 10
Hookworm	(0) 0	(13) 6	(4) 3
Cryptosporidium	(0) 0	(59) 27	(37) 25
Schistosoma haematobium	(9) 2	(15) 7	(6) 4
Dpyldum	(0) 0	(15) 7	(6) 4
Schistosoma mansoni	(13) 3	(2) 1	(7) 5
Schistosoma japonicum	(0) 0	(7) 3	(4) 3
Hymenolepis nana	(0) 0	(2) 1	(3) 2
Trichuris trichura	(13) 3	(17) 8	(6) 4
Taenia egg	(4) 1	(7) 3	(1) 1
Fasciola spp	(0) 0	(13) 6	(1) 1
Lymniea	(0) 0	(4) 2	(7) 5
Giardia (Trophozite)	(0) 0	(2) 1	(6) 4
Enterovious	(0) 0	(20) 9	(0) 0
Cilindro	(13) 3	(0) 0	(0) 0
Total	(14) 74	(44) 242	(42) 230

Table (2) summarizes the Physicochemical parameters of irrigation water samples collected from the study areas. The pH values ranged from 5.9 to 8.3, with the highest recorded in Al-Fayyut and Eseen (8.3). Temperature values ranged between 14°C and 23°C, which are within acceptable limits. Electrical conductivity (EC) ranged from 70.7 to 492 μs/cm, well below the permissible limit of 3000 μs/cm, with the highest values recorded in Ghat and Eseen. Dissolved oxygen (DO) and biological oxygen demand (BOD) values ranged between 0.3 and 7.6 for both, with the lowest DO in Al-Fayyut and the highest in Al-Barakat, which also recorded both the lowest and highest BOD values. Salinity levels in all study areas remained below the permissible limit of 0.2%. The lowest total dissolved solids (TDS) level was recorded in Al-Fayyut (55.6), and the highest in Al-Barakat (431).

Table (2): physical and chemical properties of irrigation water in study area.

Region	PH	Tem C°	EC μs/cm	Salinity %	BOD	DO	TDS
					Mg/l		
Al-Awinat	6.91	20.7	388.9	0.7	1.04	1.73	172.6
	7.2	21	256.5	0.6	1.16	0.82	140.17
Tahala	6.9	23	336.4	0.7	3.64	4.7	167.7
Ghat	7.2	20	471.6	1	1.3	2.4	238
	7.3	14.3	70.7	1.2	0.9	0.9	283
	7.2	23	222.8	0.4	1.4	1.5	140
	7.1	23	484	0.9	1.52	3.3	242
	7.1	23	492	0.9	5.6	5.4	240
Al-Fayyut	7.2	19	398	1	1.5	3.7	242.9
	7.2	20.7	161	0.5	1.1	0.3	133.9
	8.3	13.8	455.5	0.9	2.5	3.3	303.8
	6.6	24	315	0.6	1.9	1.7	55.6

	7.3	22	244.8	0.5	5.2	5.3	122.6
Al-barakat	7.4	19.9	205.6	0.3	1.3	1.9	143.8
	7.9	24	282.9	0.6	0.8	0.5	137
	5.9	24	244	0.9	7.6	7.6	431
	6.4	23	229	0.9	1.3	1.0	228.5
	6.7	22.9	273.7	0.5	1.5	1.9	133.5
	6.6	23	300	0.7	0.3	0.3	164.4
	6.9	21	257	0.5	6.3	5.6	124
Eseen	7.7	14.3	432.5	0.4	3.9	3.6	167.6
	8.3	14	206	0.5	2.4	2.0	129
	6.9	23	354	0.7	1.8	1.8	175

Table (3) illustrates the distribution of parasitic contamination in irrigation water used for crop production in the study areas. Al-Barakat recorded the highest parasitic presence at 18%, followed by Al-Fayyut at 16%, and Ghat at 15%. The lowest prevalence was in Tahala at 3%. The most widespread parasites across all areas were *Ascaris* worms and *Amoeba spp.*, representing 87% of the total parasite detections (20–23 cases).

Table (3): Distribution of parasitic in irrigation water.

Parasitic contamination	Positive contamination samples	Al-Awinat	Tahala	Ghat	Al-Fayyut	Al-barakat	Eseen
	No (%)	No (%)	No (%)	No (%)	No (%)	No (%)	No (%)
Ascaris worm	(87) 20	(30) 6	(5) 1	(35) 7	(15) 3	(100) 20	(25) 5
Ascaris egg	(48) 11	(27) 3	(0) 0	(64) 7	(64) 7	(36) 4	(0) 0
Ascaris lumbricoides	(22) 5	(60) 3	(0) 0	(100) 5	(0) 0	(20) 1	(0) 0
Amoeba spp	(87) 20	(15) 3	(20) 4	(20) 4	(95) 19	(35) 7	(5) 1
Clonorchis sinensis	(26) 6	(17) 1	(0) 0	(50) 3	(33) 2	(33) 2	(0) 0
Taenia egg	(4) 1	(0) 0	(0) 0	(100) 1	(0) 0	(0) 0	(0) 0
Cilindro	(13) 3	(0) 0	(0) 0	(33) 1	(0) 0	(0) 0	(0) 0
Lymniea	(22) 5	(0) 0	(20) 1	(40) 2	(20) 1	(20) 1	(0) 0
Trichuris trichura	(13) 3	(0) 0	(0) 0	(0) 0	(33) 1	((33) 1	(33) 1
Total spread to each region		(8) 16	(3) 6	(15)30	(16)33	(18)36	(4) 7

Table (4) presents the distribution of parasitic contamination in soil samples across the study areas. Al-Barakat showed the highest prevalence at 36%, followed by Al-Fayyut (24%), Eseen (18%), and Ghat (17%). *Ascaris* worms showed the highest occurrence in Al-Barakat at 44%, followed by *Amoeba spp.* at 29%.

Table (4): Distribution of parasitic prevalence of soil contaminating parasites in study area.

Soil parasites	Single parasitics contamination	Al-Awinat		Tahala		Ghat		Al-Fayyut		Al-barakat		Eseen	
	No	No	%	No	%	No	%	No	%	No	%	No	%
Ascaris worm	17	0	0	0	0	4	24	2	12	7	41	4	24
Ascaris egg	1258	40	3	31	2	160	13	240	19	550	44	237	19
Ascaris lumbricoides	353	0	0	1	0	42	12	105	30	149	42	56	16
Amoeba spp	785	0	0	24	3	217	28	190	24	224	29	130	17
Clonorchis sinensis	224	0	0	4	2	43	19	80	36	54	24	43	19
Coccidisis	8	0	0	2	25	2	25	0	0	0	0	4	50
Hookworm	8	0	0	0	0	2	25	0	0	4	50	2	25
Cryptosporidium	268	20	7	21	8	49	18	45	17	68	25	65	24
Schistosoma haematobium	21	0	0	0	0	1	5	3	14	12	57	5	24
Dpyldum	31	0	0	0	0	2	6	16	52	13	42	0	0
Schistosoma mansoni	1	0	0	0	0	0	0	0	0	1	100	0	0
Schistosoma japonicum	12	0	0	0	0	0	0	8	67	0	0	4	33
Hymenolepis nana	1	0	0	0	0	1	100	0	0	0	0	0	0

Trichuris trichura	14	0	0	0	0	2	14	7	50	5	36	3	21
Taenia egg	7	0	0	0	0	0	0	0	0	7	100	0	0
Fasciola spp	15	0	0	0	0	1	7	0	0	0	0	14	93
Lymniea	4	0	0	0	0	0	0	3	75	0	0	1	25
Giardia (Trophozite)	9	0	0	0	0	0	0	9	100	0	0	0	0
Enterobius egg	54	0	0	0	0	5	9	31	57	17	31	1	2
Total		60	2	83	3	531	17	743	24	1107	36	569	18

Table (5) summarizes the occurrence of parasitic contamination in soil, showing that most of the studied areas tested positive for more than three types of parasites in 80% of the cases. These findings were statistically significant.

Table (5): Positive soil samples and type of Parasitic polymorphism.

Region	**Total samples (46)**	**polyparasitic**				**Chi-square χ2 (p-value)**
		One type	**Two types**	**Three types**	**More than three types**	
	No	No (%)	No (%)	No (%)	No (%)	
Al-Awinat	1	0(0)	0(0)	1(100)	(0) 0	3.65 (0.895)
Tahala	1	0(0)	0(0)	0(0)	1(100)	
Ghat	9	0(0)	1(11)	2(22)	6(67)	
Al-Fayyut	12	0(0)	1(8)	1(8)	10(83)	
Al-barakat	16	0(0)	0(0)	3(19)	13(81)	
Eseen	7	0(0)	0(0)	0(0)	7(100)	
Total	46	0(0)	2(4)	7(15)	37(80)	

Table (6): details the distribution of parasitic contamination in leafy vegetables across the study areas. Al-Barakat recorded the highest prevalence at 34%, while Tahala showed the lowest at 5%. *Amoeba spp.* were the most widespread parasites with a total of 614 detections, with Al-Barakat alone accounting for 41%. In contrast, *Taenia* eggs and *Fasciola spp.* were the least detected parasites (2 cases each) in Ghat and Al-Barakat.

Table (6): Distribution of parasitic infestations of vegetables in the study area.

Vegetable parasites	Single parasitics contami-nation	Al-Awinat		Tahala		Ghat		Al-Fayyut		Al-barakat		Eseen	
	No	No	%	No	%	No	%	No	%	No	%	No	%
Ascaris worm	109	2	2	0	0	30	28	19	17	39	36	19	17
Ascaris egg	403	81	2	0	0	158	39	21	5	48	12	95	24
Ascaris lumbricoides	185	12	6	40	22	42	185	21	11	91	49	6	3
Amoeba spp	614	4	1	11	2	217	614	102	17	250	41	102	17
Clonorchis sinensis	82	0	0	3	4	43	19	10	12	42	51	14	17
Coccidisis	35	7	20	0	0	2	25	0	0	1	3	27	77
Hookworm	4	0	0	0	0	3	75	1	25	0	0	0	0
Cryptosporidium	291	8	3	39	13	72	25	15	5	110	38	47	16
Schistosoma	26	0	0	0	0	6	23	2	8	18	69	0	0
Dpyldum	20	0	0	0	0	12	60	2	10	6	30	0	0
Schistosoma mansoni	34	0	0	0	0	8	24	21	62	0	0	5	15
Schistosoma japonicum	3	0	0	0	0	3	100	0	0	0	0	0	0
Hymenolepis nana	3	0	0	0	0	2	67	1	33	0	0	0	0
Trichuris trichura	5	0	0	0	0	0	0	1	20	4	80	0	0
Taenia egg	2	0	0	0	0	2	100	0	0	0	0	0	0
Fasciola spp	2	0	0	0	0	0	0	0	0	2	100	0	0

Lymniea	15	0	0	0	0	2	13	1	7	11	73	1	7
Giardia (Trophozite)	23	0	0	8	35	0	0	6	26	9	39	0	0
Total spread		114	6	101	5	531	17	743	24	1107	36	569	18

Table (7) addresses parasitic contamination in leafy vegetables typically consumed raw. Parasites were detected in all examined samples. Swiss chard had the highest contamination rate at 31%, followed by parsley (28%) and lettuce (27%). Mint showed the lowest contamination rate at 8%.

Table (7): Number and type of Parasites in positive samples of consumed Vegetables

parasitic	positive samples	Type of Vegetables									
		Lettuce		Parsley		Chard		Mint		Arugula	
Ascaris worm	No	No	%	No	%	No	%	No	%	No	%
	24	3	13	7	29	8	33	2	8	4	17
Ascaris egg	40	10	28	12	33	9	25	3	8	6	17
Ascaris lumbricoides	23	7	33	5	24	7	33	1	5	3	14
Amoeba spp	58	17	30	14	25	15	27	5	9	7	13
Clonorchis sinensis	24	7	32	5	23	7	32	2	9	3	14
Coccidisis	2	7	20	3	30	2	20	2	20	2	20
Hookworm	1	0	33	0	0	1	33	0	0	3	100
Cryptosporidium	24	8	-	7	28	8	32	2	12	110	8
Schistosoma	0	0	0	2	50	2	50	2	0	18	50
Malbiodium	33	0	33	1	33	0	0	1	0	6	33
Schistosoma mansoni	40	0	40	4	80	1	20	0	0	1	20
Schistosoma japonicum	0	0	0	1	33	0	0	0	0	0	0
Hymenolepis nana	0	0	0	1	50	1	50	0	0	0	0
Trichuris trichura	25	0	25	2	50	2	50	1	25	0	80
Taenia egg	100	0	100	0	0	0	0	0	0	0	0
Fasciola spp	0	0	0	0	0	1	100	0	0	0	0
Lymniea	0	0	0	1	20	3	60	0	0	1	20
Giardia (Trophozite)	3	0	60	0	0	4	80	0	0	0	0
total		61	27	65	28	71	31	19	8	35	15

Table (8) presents the number of vegetable samples examined and the proportion of contaminated samples. Out of 66 vegetable samples, 60 tested positive, reflecting a contamination rate of 91%. About 47% of the samples contained more than three types of parasites, indicating mixed infections, while 3% showed single-parasite contamination.

Table (8): Number and type of Vegetable samples and type of Parasitic polymorphism.

Type of vegetables	Number of samples examined	Number of contaminated samples	polyparasitic				Chi-square χ2
			One type	Two types	Three types	More than three types	(p-value)
Lettuce	No	No (%)	No (%)	No (%)	No (%)	No (%)	18.23 (0.003)
	15	14(93)	0(0)	2(14)	6(43)	6(43)	
Parsley	17	16(94)	1(6)	4(25)	4(25)	7(44)	
Chard	16	16(100)	0(0)	1(6)	3(19)	11(69)	
Mint	7	4(57)	1(25)	0(0)	0(0)	4(100)	
Arugula	11	10(91)	1(10)	2(20)	3(30)	3(30)	
total	66	60(91)	3(5)	7(12)	13(22)	28(47)	

Discussion:

Human public health is directly influenced by the quality of food consumed on a daily basis. It is the responsibility of governmental authorities in food and health sectors to ensure appropriate sanitary conditions and continuous monitoring to guarantee food safety throughout all stages of production, ensuring it is free from disease-causing agents [2, 27].

In Libya, many previous studies on parasitic contamination have focused solely on one stage of the food production chain primarily the post-harvest stage thereby limiting their scope to vegetable contamination [8, 9, 20, 28]. However, the present study uniquely examined parasitic contamination across all stages, from irrigation to harvest. It revealed 20 different pathogenic parasites contaminating irrigation water, soil, and vegetables. The prevalence of parasitic contamination in irrigation water was 14%, which exceeds the World Health Organization (WHO) guideline of less than (1 helminth egg per liter) for water used in crop irrigation to safeguard public health [10].

Regarding the physicochemical quality of water, parameters such as pH, temperature (°C), and salinity were within acceptable limits according to the Food and Agriculture Organization (FAO) recommendations [29]. In addition, total dissolved solids (TDS) values in all study areas remained within permissible limits (acceptable if < 450 mg/L) [30]. Such water supports plant growth by enhancing water absorption, improving soil structure, and increasing water retention capacity [31]. However, if TDS exceeds 450 mg/L, the resulting salinity can adversely affect plant growth. In this study, TDS values ranged from 303.8 to 431.4 mg/L in Al-Barakat and Al-Fayyut, respectively. These findings are consistent with a study conducted in the eastern Nile Delta (3), where TDS values ranged from 222.27 to 407.4 mg/L in certain canals, while higher values (577.8–806.4 mg/L) were observed in others due to the discharge of agricultural and industrial wastewater, increasing irrigation water salinity.

Electrical conductivity (EC), an important indicator of plant productivity and water ion concentration, was also measured. When EC exceeds acceptable levels, soil ions compete with crops for water, reducing availability [32,33]. In this study, EC values remained within FAO-recommended limits (29).
Dissolved oxygen (DO) values ranged from below 3 mg/L to above 6 mg/L, corresponding to WHO classification levels II and V for irrigation water. The highest DO value (7.6 mg/L) was recorded in Al-Barakat. These findings align with studies conducted in the Bogotá savanna (Colombia) and Morocco [10, 34], which attributed high DO levels to irrigation with contaminated water, leading to enhanced biological activity. Similarly, this study found that Al-Barakat had the highest parasitic contamination levels, where many farmers used open-source irrigation tanks exposed to both human and animal contamination.

Regarding biological oxygen demand (BOD), optimal irrigation water values should be below 10 mg/L. Most samples in the study met this criterion. Low BOD levels are beneficial to crops as they improve soil aeration and nutrient uptake. Conversely, high BOD levels indicate accumulation of organic matter from human or animal sources, which may harbor parasites, deplete dissolved oxygen, hinder soil aeration, damage plant roots, and lead to crop failure [35].

The present study revealed a high prevalence of parasites in soil, estimated at 44%, which aligns with previous research in Egypt, where the parasitic contamination rate of soils near the Mayas Canal was 40.8%, and in Eritrea, where it reached 35%. These studies attributed the contamination to several factors: parasitic structures embedded within soil particles, making them hard to separate [36]; contamination from untreated irrigation water; and the use of livestock manure [37]. Such factors were evident in the current study areas, where the sampled channels had clay-rich soils and animal waste residues, used as organic fertilizer by farmers. These findings are supported by results from studies [38,39,40].

In contrast, lower levels of parasitic contamination were reported in a Brazilian study (20%), which was attributed to the acidic pH of the soil, reducing the survival of parasite eggs and consequently lowering the likelihood of obtaining positive samples.

In this study, a high level of parasitic contamination was detected in the examined vegetables, with a contamination rate of approximately 42%. These results are consistent with findings from previous studies conducted in Ethiopia, which reported a contamination rate of around 42.6% [41], in Minya, Egypt at approximately 40%, in Iraq at 49.8% [42], in Alexandria, Egypt at 46.7%, in Eritrea at 42.9%, and in the Kurdistan region of Iraq at 48.4% [43]. Similarly, a study conducted in Zahedan, Iran reported a parasitic contamination rate of 44.8% [44].

In contrast, lower contamination levels were observed in studies conducted in the United Arab Emirates (15%), Saudi Arabia (16.2%) [45], northern Lebanon (16.6%) [46], and Tehran, Iran (25.8%) [47]. The variation in these results may be attributed to differences in sampling techniques, handling methods, and agricultural practices, particularly in how farmers manage crops before and after harvest [48]. Climatic and environmental conditions, geographical nature, and socio-economic and health awareness factors may also contribute to the observed differences [49, 50].

The study revealed that *Ascaris* eggs were among the most widespread parasites found in both soil and vegetables. The highest contamination levels were recorded in Al-Barakatand Ghat at 44% and 39%, respectively. *Ascaris* eggs are known to mature easily in high temperatures, with the recorded temperatures in these areas ranging between 19°C and 24°C. These findings are in agreement with previous studies [51], which showed that the eggs have high fertility, with female worms capable of producing over 200,000 eggs, enhancing the likelihood of transmission. Moreover, the eggs demonstrate significant resistance to unfavorable environmental conditions and can persist in soil for extended periods, especially when humidity and heat.

Amoeba spp. ranked as the second most prevalent parasite, with a detection rate of 95% in irrigation water samples from Al-Fayyut and 28–29% in soil samples from Ghat and Al-Barakat, respectively, and 41% in vegetables grown in Al-Barakat. *Amoeba spp.* are commonly found in water due to their resistance to treatment processes. Their presence may also be linked to the abundance of animal hosts such as livestock and stray dogs in the study areas. These results align with a study conducted in Khorramabad, Iran, where a 40% contamination rate was found in vegetables [52], as well as studies [53] that attributed contamination to cycles of animal, human, and environmental waste particularly via irrigation water and soil runoff during the rainy season.

Ascaris lumbricoides and *Ascaris worm* were the third most commonly found parasites, particularly in soil and vegetables. *Ascaris lumbricoides* was detected at prevalence rates of 42% and 49% respectively in Al-Barakat, while *Ascaris worm* was found in 100% of irrigation water samples, 41% of soil samples, and 36% of vegetable samples all peaking in Al-Barakat. These high rates are likely due to the area's environmental conditions, including heat, drought, and clay soil composition. Similar results were reported in other studies [54-56], where prevalence ranged between 56.3% and 89%. The durability of the eggs under harsh conditions and their ability to remain viable in anaerobic soil for up to two years at temperatures between 5°C and 10°C, and to withstand desiccation for 2–3 weeks, were noted as contributing factors [57- 59].

The study also found that *Cryptosporidium* and *Clonorchis sinensis* were among the parasites detected in vegetables, soil, and water. *Cryptosporidium* was found at the highest rates of 38% and 25% in Al-Fayyut and Al-Barakat, respectively, though it was absent in irrigation water samples. *Clonorchis sinensis* was detected at 50% in Ghat, 36% in Al-Fuyyut, and 51% in Al-Barakat across water, soil, and vegetable samples. The presence of these parasites may be linked to irrigation methods specifically, the use of sprinklers, which facilitate direct contamination of vegetables. These findings are consistent with studies [2,14,25,48] that reported *Cryptosporidium* in Brak Al-Shati (16%), Eastern Nile Delta (26%), Alexandria (29%), and Spain (24%). These studies concluded that the parasites are primarily introduced through contaminated irrigation water. As their eggs cannot survive long in water, they tend to settle in soil and subsequently adhere to vegetable surfaces, especially with sprinkler irrigation.

Other parasites such as *Coccidiosis*, *Hookworm*, *Trichuris trichiura*, *Giardia*, and *Schistosoma* were found at lower rates but are still considered significant public health concerns. Several unfavorable conditions were observed in the contaminated areas, including free-roaming domestic animals near agricultural canals, the use of untreated manure, contaminated open water sources, and mixed cropping systems, all contributing to the contamination of soil and vegetables. These findings are consistent with studies [60-62].

The study recorded the highest contamination level in chard (31%), followed by Parsley, lettuce (28 -27%) and Arugula (15%), while the lowest contamination was in mint (8%). These findings vary somewhat from studies [8,18,23,26,28,43,63], though they concur that vegetables with uneven, wide surfaces and irregular leaves facilitate the adherence of parasitic eggs and cysts. Moreover, these vegetables often have short, flexible stems that increase contact with soil and irrigation water. The overlapping structure of leaves, as seen in lettuce and Al-Barakat, may also provide shelter for parasites.

Finally, the study observed multifarities in both soil and vegetables. More than three parasite species were found in 80% of soil and 47% of vegetable samples. Triple-species contamination was observed in 22% and 15%, respectively, while dual contamination occurred in 4% of soil and 12% of vegetable samples. Single-species contamination was not recorded in soil and was only 5% in vegetables. This high diversity suggests a significant level of environmental contamination, posing direct or indirect risks to public health. These results align with those of study [43], which observed multiple parasitic infections in 8% of samples, and noted even higher rates in vegetables. The variability was attributed to differing social, economic, environmental, and climatic conditions in the study areas.

Conclusion

Identifying the key factors contributing to the spread and prevalence of pathogenic organisms in communities is critical to formulating appropriate intervention strategies. Based on the findings of this study on parasitic contamination, the following recommendations may help limit the spread of parasites and their impact on public health:

- Educate farmers on proper agricultural practices, including regular monitoring of water quality and avoiding exposure of irrigation sources to animals and birds, which significantly contribute to parasitic contamination.

- Raise awareness among producers regarding the risks of using untreated manure on soil and vegetables, and establish monitoring mechanisms across all stages of production, from planting to harvesting, to ensure minimal contamination.
- Since most vegetables, especially leafy greens, are consumed raw, the health sector should promote hygiene education for both producers and consumers to minimize the risk of transmitting infective parasitic stages.

The findings of this study underscore the importance of continuous surveillance of parasitic contamination and the need for coordinated efforts among food safety stakeholders. Collaboration between academic institutions and the ministries of agriculture and health is essential to conduct further epidemiological studies aimed at tracking parasites in various environmental samples and minimizing the spread of parasitic diseases.

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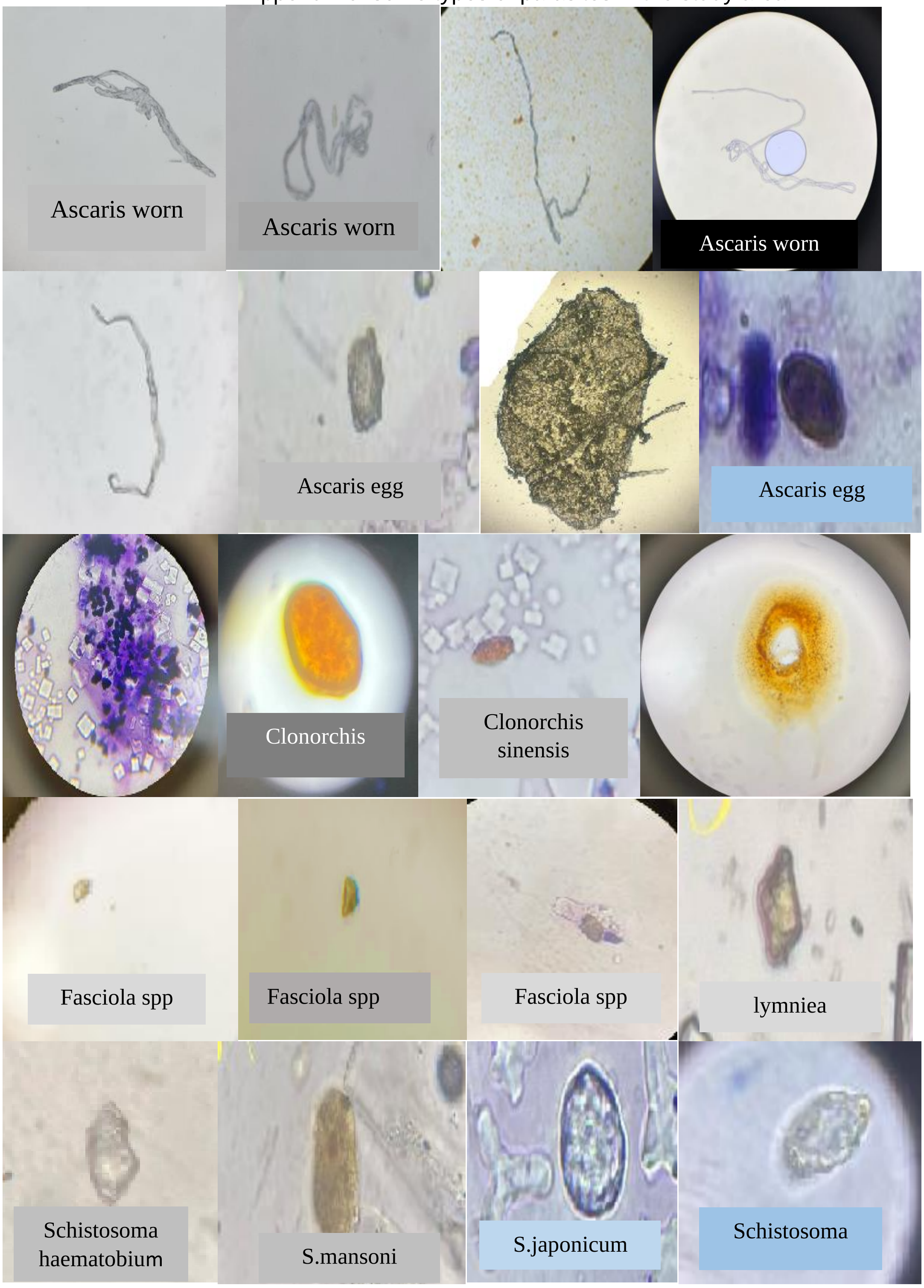
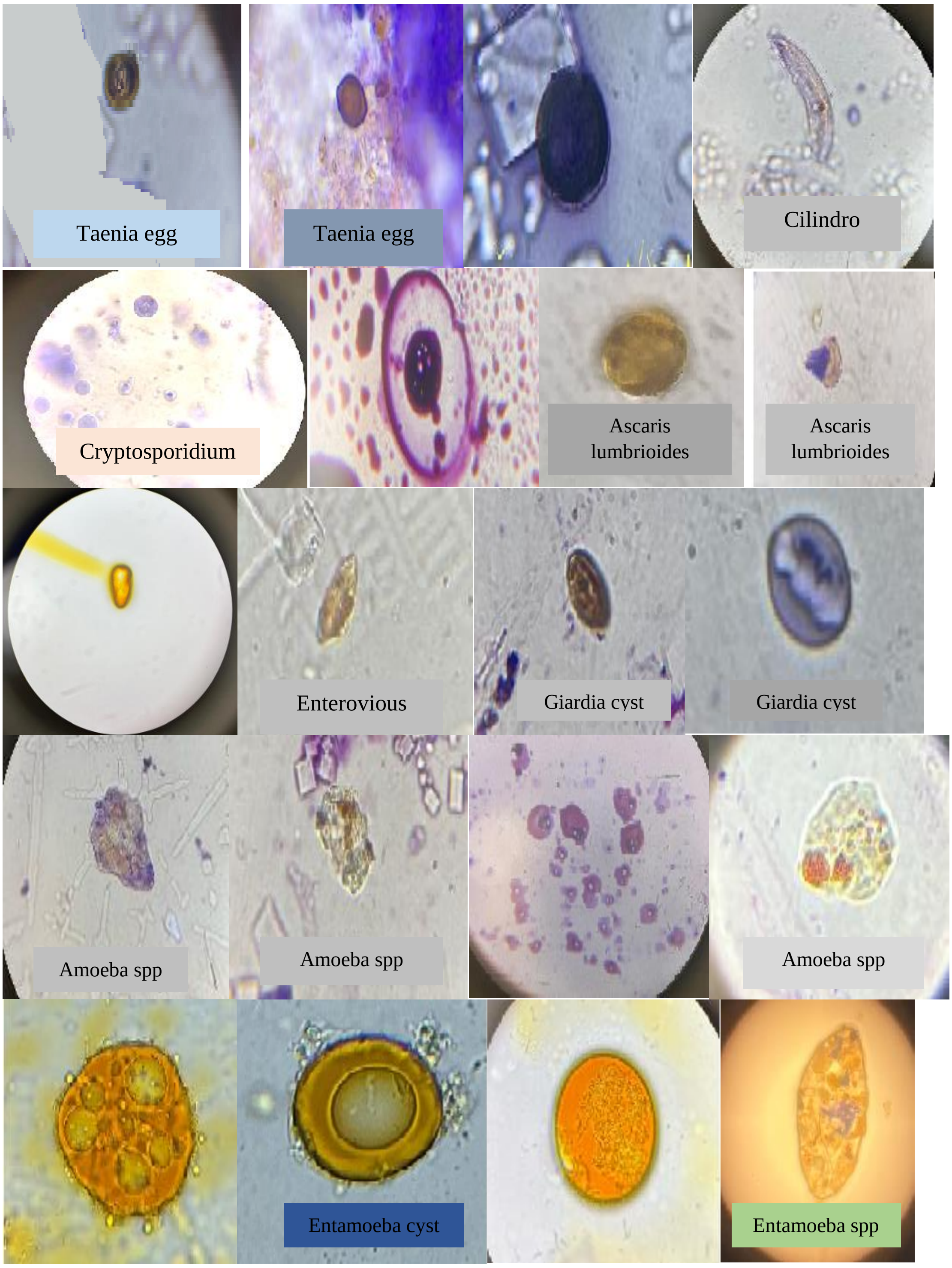
Appendix of some types of parasites in the study area




Taenia egg
Taenia egg
Cilindro
Cryptosporidium
Ascaris lumbrioides
Ascaris lumbrioides
Enterovious
Giardia cyst
Giardia cyst
Amoeba spp
Amoeba spp
Amoeba spp
Entamoeba cyst
Entamoeba spp


Ancylostom
Hymenolepis nana
Hookoorm
Dpyldum
Dpyldum
Trichuris