Pollution of irrigation water in East Nile Delta, Egypt: Physicochemical and parasitological studies

Original Article

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ABSTRACT

Background: Irrigation water quality is important for the cultivation of safe food products and suitable soil for vegetables and fruits.
Objective: To evaluate the irrigation water quality in Sharkia Governorate, Egypt; for possible parasitological contamination.
Material and Methods: A water sample (2-3 liters) was collected monthly from the main 5 irrigation canals in Sharkia Governorate (total = 60). They were examined physiochemically including pH, turbidity, electrical conductivity (EC), total dissolved salts (TDS), and heavy metals. Samples were also microfiltered, centrifuged, and washed. Both supernatant and sediment of each water sample were microscopically examined for parasitic pollution by direct, iodine stained smears, and modified Ziehl–Neelsen method.
Results: Physicochemically, samples showed seasonal variation with increased EC and TDS in the winter, whereas heavy metals were recorded in low permissible levels. All canals showed parasitic contamination, where *Cryptosporidium* oocysts, and *Giardia* cysts were the most frequent parasites detected in all irrigation canals. The highest prevalence was recorded in summer and spring.
Conclusion: Our results showed that monitoring irrigation water quality is essential for maintaining a safe food supply and avoiding harmful health risks.

Keywords: *Cryptosporidium* spp.; *G. duodenalis*; heavy metals; irrigation water; parasitic pollution; physicochemical parameters; soil transmitted parasites.

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INTRODUCTION

Water, a vital source for life, is becoming increasingly inaccessible, posing a quick growing challenge all over the world[1]. Agriculture utilizes 92% of the water consumed worldwide[2]; out of which, around 70% of freshwater is utilized in irrigation[3]. Recorded data on availability raises severe concerns for countries experiencing water shortages. According to Shen *et al.*[4], 40% of the world's population is exposed to deficient water supply, reflecting a water problem for irrigation[5].

Egypt faces numerous difficulties in this issue, the most significant of which is the continuous reduction in the amount of water available per capita in the last years, which decreased to 561.9 m^3/year[6]. This insufficiency will reach a peak following the Ethiopian Renaissance Dam's completion, which presents a significant danger to Egypt's and Sudan's water supplies[7]. Unfortunately, Egyptian farmers are compelled to use treated sewage water for irrigation. Furthermore, with the absence of a good sanitation network in several areas, some residents dispose of sewage water in nearby water streams[8]. According to these circumstances, infectious diseases linked to water may be transmitted. Therefore, assessing the water quality used in irrigation is critical for ensuring food safety for consumers[9]. Alegbeleye *et al.*[10] claimed that polluted irrigation water acts as a source of microbial pathogens that contaminate cultivated fruits and vegetables, and present a health risk to humans.

Microorganisms causing water-borne diseases include viruses, bacteria, and parasites[11]. Parasitic infections from water resources are considered a public health issue particularly in less developed countries[12]. Among these parasites, there are certain protozoa that cause serious health problems[13].

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Several outbreaks caused by consumption of water polluted with *G. duodenalis*, *E. histolytica/dispar*, *Cryptosporidium* spp., and *C. cayetanensis* were recorded worldwide[14]. Poor quality and sanitation practices of irrigation water are also considered a major risk factor for soil-transmitted helminths (STHs), which reportedly infect over 1.5 billion people worldwide[15]. The nematodes; *A. lumbricoides*, *T. trichiura*, and hookworms (*A. duodenale,* and *N. americanus*), *S. stercoralis*, and hydatid disease caused by the dog cestode *Echinococcus* spp. are among the most common STHs[16]. They contaminate water streams by direct defecation or due to sewage drains, and water/ rain overflow from polluted soil that uses man and animal excreta as fertilizer[16]. Besides hydatid disease, other helminthic infections that have been linked to ingestion of inadequately washed raw vegetables and fruits irrigated with polluted water include fascioliasis, hymenolepiasis, and toxocariasis[17]. The classification of helminthic infections as high risk compared to other infectious diseases is because of their low transmittable doses, possible resistance to treatment, and ability to endure changes in the environment[18].

Furthermore, toxic chemical contamination of water due to pollutants from industrial and consumer wastes, is extensively identified as an environmental hazard[19]. Chemical pollutants include organic compounds, disinfection by-products, heavy metals, and other complexes[20]. Heavy metals are hazardous as they are non-degradable and tend to bio-accumulate *via* exposed food products. Their high levels in food pose a health risk specially on the long-term, predisposing to cancer, impaired immune system, nervous system disorders, and organ damage[21,22]. Therefore, the WHO recommends monitoring water quality and its content of microbial contaminants[18].

A water supply with a high parasite load and increased heavy metal content could affect the irrigated food's quality and expose several individuals (farmers, consumers, and nearby inhabitants) to parasitic infections and numerous health problems[9,23]. It is essential to resolve issues related to the increasing demand for freshwater, pending water depletion, and reuse wastewater[2,5]. Therefore, our present study aimed to assess the physicochemical and parasitological aspects of irrigation water sources in the Sharkia Governorate, Egypt. Up to our knowledge, this is the first study to evaluate pollution and physicochemical parameters of irrigation water in the East of Nile Delta in a trial to complete strategies for controlling irrigation water pollution in Egypt.

MATERIAL AND METHODS

This observational analytical study was conducted in the Medical Parasitology Department, Faculty of Medicine, and the Central Laboratory for Soil, Food and Feed Stuff (CLSFF), Faculty of Technology and Development, Zagazig University, Sharkia Governorate, Egypt during the period from December 2022 to November 2023.

Study design: Water samples were collected from El-Ganabia, Sherwida, El-Mahmodyia, El-Senety, and Saft Zerek canals. These canals are the source of irrigation for nearby agricultural fields and farms in different agricultural areas in Sharkia (Fig. 1). Water samples were collected monthly for a period of one year to evaluate their physicochemical parameters, and parasitic contamination.

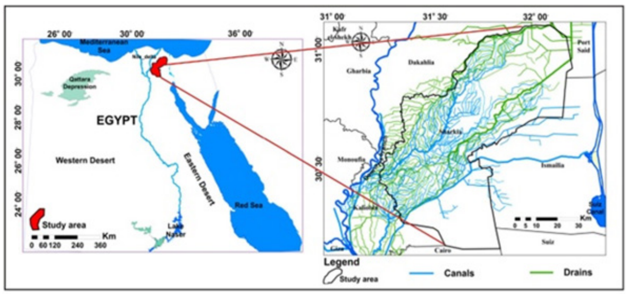

Fig. 1. Canals and drains in Sharkia Governorate in the East of the Nile Delta, Egypt[24].

Collection of water samples: Sixty surface water samples were collected; 12 from each irrigation canal at different sites along its course. Clean labeled polystyrene bottles were used to collect 2-3 liters of water. Samples for heavy metal detection were acidified with concentrated nitric acid (pH 2.0) and transported to the laboratory in a cool icebox (4°C) on the same day of collection. The samples were analyzed immediately upon arrival at the laboratory.

Physicochemical analysis: Water samples were analyzed at Central Laboratory for Soil, Food and Feed Stuff (CLSFF), Faculty of Technology and Development, Zagazig University according to standard methods[25,26]. The analyzed parameters included water temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), and turbidity. Additionally, heavy metals (Cu, Mn, Fe, Zinc, Pb) in water samples were measured using a flame atomic absorption spectrophotometer (Savanta AAS with GF 5000 Graphite Furnace); the pH value was determined by a calibrated pH meter (Model: YK-2001PH, Lutron, Kuala Lumpur, Malaysia). The EC and TDS were measured by a portable meter (Model: CD-4306, Lutron). Potable water analysis instrumentation (HACH) was used[27].

Parasite detection in water samples: For matched parasitological analysis, the samples were transported to the laboratories of the Medical Parasitology Department, Faculty of Medicine, and Zoology Department, Faculty of Science, Zagazig University. The water samples were filtered through a nitrocellulose membrane filter (0.45 mm pore size, and 142 mm diameter, Sartorius Stedim Biotech, Goettingen, Germany)[28]. The membrane filter was washed three times with sterile physiological saline (0.85 NaCl). The filtrate was then centrifuged at 2000 g for 5 min[29]. The supernatant and the sediment of each sample were examined. The supernatant was examined by the Zinc-sulfate flotation method to detect lightweight eggs and protozoan cysts[30]. The sediment was examined by saline and Lugol's iodine-stained smears for parasites identification[31]. Two smears from each sample were air dried, fixed with methanol, and stained by Giemsa stain[32] and modified Ziehl-Neelsen stain[33]. Parasites were identified based on their size and morphology using microscopy at different magnifications[34].

Statistical analysis: Data were checked, entered, and analyzed by using SPSS version 22. Data were represented as mean for quantitative variables, numbers, and percentages for categorical variables. The chi-square test (X^2) test was used to compare qualitative data. Statistical significance is considered when P is ≤0.05.

Ethical consideration: The study was approved by the Research Ethics Committee, Faculty of Medicine, Zagazig University, Egypt (ZU-IRB#10088/7-12-2022).

RESULTS

Physicochemical parameters: The physicochemical parameters of water samples collected from the studied irrigation canals in Sharkia Governorate are summarized in table (1). The pH values in the studied canals ranged from 6.60 to 7.74 (normal from 6.5 to 8.4). The EC values ranged from 348 to 1250 µS/cm during the different seasons (permissible up to 3000 µS/cm). Saft Zerek canal recorded the highest EC values during the four seasons, particularly in the winter (1250 µS/cm). The TDS values ranged from 222.72 to 806.4 mg/L (accepted less than 450 mg/L). The highest values were found in samples from Saft Zerek canal particularly in winter (806.4 mg/L). Turbidity showed a wide variation from 0.8 to 86.8 nephelometric turbidity units (NTU) (accepted less than 2 NTU). The maximum turbidity values were detected in the Sherwida canal during the four seasons, especially during summer (86.8 NTU) followed by spring (84.3 NTU). The minimum turbidity value was during autumn at El-Mahmodyia canal (0.9 NTU). Regarding the heavy metals Fe, Cu, and Mn were variably detected in the irrigation water samples studied (maximum accepted concentrations: 5 mg/L, 0.2 mg/L, and 0.2 mg/L, respectively), while Zn and Pb were not detected in any of the samples (maximum accepted concentrations: 2 mg/L and 5 mg/L, respectively).

Parasitological results: Results showed that forty-three samples (71.7%) out of sixty were positive for parasites. The Sherwida canal showed the highest level of parasitic contamination (91.7 %), and the lowest rates were in El-Mahmodyia and Saft Zerek irrigation canals (Table 2) with significant single parasitic pollution (Table 3).

Regarding seasonal variation of parasitic infections, the highest level of contamination was found in summer followed by spring (86.7% and 73.3%, respectively), with insignificant differences between seasons (Table 4).

There were significant differences in the detection rates of single parasite contamination in the irrigation water samples studied. The most frequently detected

Table 1. Seasonal physicochemical parameters of irrigation water in different studied canals in Sharkia Governorate, Egypt.

Season	Canals	Physicochemical characteristics				Heavy metals		
		pH	EC	TDS	Turbidity	Cu	Mn	Fe
Winter	El-Ganabia	7.63	406	259.84	6.5	ND	ND	ND
	Sherwida	7.13	636	407.04	26.8	ND	0.108	0.146
	El-Mahmodyia	6.60	840	577.84	9.06	ND	0.14	0.544
	El-Senety	7.64	413	264.32	3.5	ND	ND	ND
	Saft Zerek	7.74	1250	806.4	16.8	0.09	0.149	0.092
Spring	El-Ganabia	7.06	348	222.72	1.2	ND	ND	ND
	Sherwida	7.34	434	277.76	84.3	ND	0.153	2.62
	El-Mahmodyia	6.61	739	472.96	8.06	ND	0.12	1.657
	El-Senety	7.62	355	227.2	18.2	0.174	ND	0.391
	Saft Zerek	7.68	981	627.84	8.05	0.204	0.20	0.815
Summer	El-Ganabia	7.08	357	242.27	1.4	ND	0.182	0.211
	Sherwida	7.84	457	286.74	86.8	0.08	ND	0.213
	El-Mahmodyia	6.65	793	482.88	8.09	ND	ND	0.255
	El-Senety	7.65	375	255.4	17.5	ND	ND	ND
	Saft Zerek	7.66	991	737.48	9.05	ND	ND	0.61
Autumn	El-Ganabia	7.28	374	239	8.3	ND	0.152	0.097
	Sherwida	7.31	405	259	50.8	0.06	0.12	0.18
	El-Mahmodyia	7.22	402	257	0.9	ND	0.11	0.175
	El-Senety	7.26	396	253	12.6	ND	ND	ND
	Saft Zerek	7.51	1100	704	17.5	0.05	0.132	0.08

ND: Not detected; **EC:** Electrical conductivity; **TDS:** Total dissolved solids.

Table 2. Parasitic contamination in irrigation water sources in Sharkia Governorate, Egypt.

Canals	Positive	Negative	Total	Statistical analysis
	No. (%)	No. (%)	No. (%)	
El-Ganabia	8 (66.7)	4 (33.3)	12 (100)	X^2 = 5.42 P = 0.24**
Sherwida	11 (91.7)	1 (8.3)	12 (100)	
El-Mahmodyia	7 (58.3)	5 (41.7)	12 (100)	
El-Senety	10 (83.3)	2 (16.7)	12 (100)	
Saft Zerek	7 (58.3)	5 (41.7)	12 (100)	
Total	**43 (71.7)**	**17 (28.3)**	**60 (100)**	

X^2: Chi-square; **: Non-significant (P>0.05).

parasite was *Cryptosporidium* oocysts (27.02%), followed by *G. duodenalis* cysts (24.32%), nematode larvae (16.22%), *E. histolytica/dispar* cysts (5.41%), and *A. lumbricoides* eggs (5.41%). Also, *Taenia, Toxocara*, and *Fasciola* eggs were each detected with the same percentage of 2.7%; commensal, *E. coli* cysts (8.11%) were also detected (Table 5).

Mixed parasitic infection was found in 6 samples: *Cryptosporidium* spp. and *G. duodenalis* were found in 2 samples; *E. coli, E. histolytica/dispar*, and *Blastocystis* spp. vacuolar form were detected in 2 samples. Nematode larvae, and *A. lumbricoides* egg were found in one sample. *Cryptosporidium* oocysts, *B. coli* cysts, and *Toxocara* eggs were found in one sample (Fig. 2).

Table (6) shows the distribution of single parasitic contamination detected in the studied canals where *Cryptosporidium* spp. and *G. duodenalis* were detected in all irrigation water canals.

Table 3. Singel and mixed parasitic pollution detected in irrigation water samples in Sharkia Governorate, Egypt.

	No. (%)	Statistical analysis
Total single	37 (86.05)	X^2 = 44.7
Total mixed	6 (13.95)	P < 0.001*

X^2: Chi-square; *: Significant (P<0.05).

Table 4. Seasonal variation of parasitic contamination in the irrigation canals studied.

Season	Positive	Negative	Total	Statistical analysis
	No. (%)	No. (%)	No. (%)	
Winter	9 (60)	6 (40)	15 (100)	X^2 = 2.87 P = 0.4**
Spring	11 (73.3)	4 (26.7)	15 (100)	
Summer	13 (86.7)	2 (13.3)	15 (100)	
Autumn	10 (66.7)	5 (33.3)	15 (100)	
Total	**43 (71.7)**	**17 (28.3)**	**60 (100)**	

X^2: Chi-square; **: Non-significant (P>0.05).

Table 5. Single parasite contamination in irrigation water samples in Sharkia Governorate, Egypt.

Parasitic stage	No. (%)	Statistical analysis
***Cryptosporidium* oocysts**	10 (27.02)	X^2 = 31.26 P < 0.001*
***G. duodenalis* cyst**	9 (24.32)	
Nematodes larvae	6 (16.22)	
***E. coli* cyst**	3 (8.11)	
***E. histolytica/dispar* cyst**	2 (5.41)	
***Blastocystis* vacuolar form**	2 (5.41)	
***A. lumbricoides* egg**	2 (5.41)	
***Taenia* egg**	1 (2.7)	
***Toxocara* egg**	1 (2.7)	
***Fasciola* egg**	1 (2.7)	
Total	37 (100)	

X^2: Chi-square; *: Significant (P<0.05).

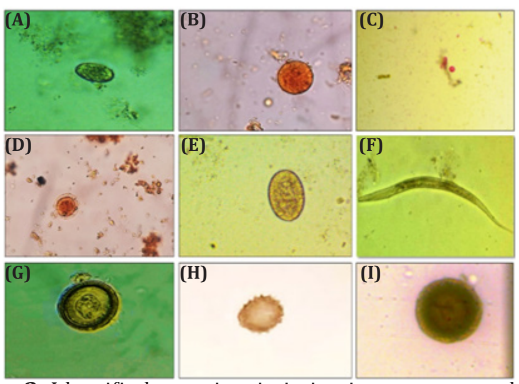

Fig. 2. Identified parasites in irrigation water samples. **A)** *Giardia* cyst; **B)** *Entamoeba* cyst; **C)** *Cryptosporidium* oocyst; **D)** *Blastocystis* vacuolar form; **E)** *Fasciola* egg; **F)** Nematode larva; **G)** Taenia egg; **H)** *A. lumbricoides* egg; **I)** Toxocara egg.

Table 6. Distribution of single parasitic contamination in the studied irrigation canals.

Parasitic stage	Canals						Statistical analysis	
	El-Ganabia	Sherwida	El-Mahmodyia	El-Senety	Saft Zerek	Total	X^2	P
***G. duodenalis* cyst**	1	3	2	2	1	9	0.6	0.9**
***E. histolytica/dispar* cyst**	0	1	1	0	0	2	3.4	0.49**
***E. coli* cyst**	0	1	0	1	1	3	1.99	0.73**
***Cryptosporidium* oocyst**	3	2	1	3	1	10	3.2	0.52**
***Blastocystis* vacuolar form**	0	1	0	1	0	2	2.29	0.68**
Nematode larvae	2	1	1	0	2	6	4.4	0.34**
***A. lumbricoides* egg**	0	1	0	0	1	2	3.1	0.54**
***Taenia* egg**	0	0	0	1	0	1	3.7	0.44**
***Toxocara* egg**	0	0	1	0	0	1	4.4	0.34**
***Fasciola* egg**	0	0	1	0	0	1	4.4	0.34**

X^2: Chi-square; **: Non-significant (P>0.05).

DISCUSSION

Water pollution is one of the most significant risks facing both developed and developing countries[35]. Due to population growth, new irrigated agricultural projects, and other activities along the Nile, the pollution of Egypt's River Nile systems has risen over the last years[36]. The quality of irrigation water has become a major concern on a global scale due to the difficulties of agricultural growth and climate change[37]. So, in this study, we evaluated the irrigation water quality in Sharkia by assessing the physicochemical and parasitological parameters. Measurement of pH is an important chemical parameter that determines the quality of irrigation water[38]. In general, pH measures the level of acidity or alkalinity and indicates the chemical reaction of water[39]. In our study, pH values ranged between 6.60 and 7.74, and were within the acceptable limit for irrigation water according to Food and Agriculture Organization (FAO) standards (from 6.5 to 8.4)[40].

Values of pH outside this range may result in nutritional imbalance and poor quality of water. Besides, EC is an indicator of ionized water constituents[41]. The primary effect of high EC on crop productivity is the inability of the plant to compete with ions in the soil for water; the higher the EC, the less water is available to plants. The EC in the current study ranged from 348 to 1250 µs/cm, with increased EC in winter in all canals. Saft Zerek Canal recorded the highest EC values during the four seasons, while the minimal values were recorded in El-Ganabia Canal. A similar finding was previously reported[9]. Increased EC during winter may be caused by water stagnation and decreased water level in the Nile River when the High Dam gates are closed. Additionally, it could be a sign that the canal is receiving much runoff and/or intense industrial contamination and the presence of mineral ions. The EC readings in our study were within the permissible limit as recommended by FAO, which is up to 3000 µs/cm[42].

The TDS measure the concentration of salts dissolved in water[38]. These soluble salts have an impact on plant growth by rendering it harder for plants to absorb water from the soil[43]. Additionally, salts can affect the soil structure and reduce its ability to store water[44]. In our study, TDS concentrations were between 222.72 and 806.4 mg/L. Samples from the Saft Zerek canal, particularly during the winter, had the highest solids levels, (806.4 mg/L). El-Mahmodyia water samples also showed a high level of TDS during winter (577.84 mg/L) but less than that of Saft Zerek. The current data are in close agreement with those who recorded high TDS levels during winter[45,46], but they differ from those who detected the largest levels during spring[47]. High levels of TDS may be caused by agricultural sewage leakage[47]. Irrigation water samples exceeding 300 mg/L indicate an increase of dissolved salts and that may be due to the discharge of agricultural and industrial drains.

Another important physical parameter of water is turbidity. It results from the presence of suspended and colloidal particles in water. Irrigation water turbidity affects physical soil characteristics. In our study, turbidity analysis of water samples showed wide variation that ranged from 0.9 to 86.8 NTU. At Sherwida canal, turbidity levels peaked during all four seasons; however, summer (86.8 NTU) and spring (84.3 NTU) were the seasons with the highest levels. The lowest value was in autumn at El-Mahmodyia canal (0.9 NTU). Ghanem[48] also detected the maximum turbidity during spring. The Uunited States Environmental Protection Agency (USEPA) recommends less than 2 NTU for directly consumed crops and unrestricted irrigation. Whereas Spain recommends levels lower than 10 NTU for vegetables[49]. High turbidity levels can affect irrigation water quality; it can also reduce soil hydraulic conductivity and pollute the soil surface through surface flow[49]. Additionally, a variety of microorganisms adhere to and move along with the solid particles, so the removal of suspended solids is connected to the elimination of microbes and improving quality of irrigation water[20].

Surface water may get contaminated with heavy metals, lowering the irrigation water quality. Due to their toxicity, persistence, and bio-accumulative nature in the environment, heavy metals are considered serious pollutants, and most countries specifically limit their quantities[50]. We recorded the presence of Fe, Cu, and Mn in several of the examined irrigation water samples. Whereas lead and zinc were not detected in any of the irrigation water samples analyzed. The concentrations of detected heavy metals in all analyzed water samples are within the recommended limits by FAO and USEPA[49].

The presence of human pathogenic parasites in irrigation water utilized in the cultivation of fruits and vegetables suggests a risk of infection for consumers who come in contact with or eat these products[51]. Egypt has few studies on the incidence of irrigation water contamination with parasites that have medical and zoonotic importance, despite the prevalence of intestinal parasites. If our goal is to control parasitic diseases, it is not sufficient to depend just on the control of the recognized cases. It is instead necessary to make an effort to decrease and eliminate the most likely sources. In Egypt, sewage is subjected to minimal treatment, and the effluent is discharged into the Nile River, lakes, and sea[52]. Waste and debris were dumped carelessly into the watercourses, and the presence of trees offered cover for defecating people and maturing helminthic larvae and eggs[53].

Irrigation with polluted water increased in some areas in Sharkia Governorate due to scarcity of pure canal water and contamination from illegal sewage disposal. In the current study, Sherwida canal showed the highest number of positive samples of parasitic contamination (91.7%), followed by El-Senety (83.3), El-Ganabia (66.7%), Saft Zerek (58.3%), and El-Mahmodyia (58.3%). The sort of pollution depends on where the canal is located. The canal is more likely to get polluted with sewage disposal the closer it is to population dwelling. As seen in the Sherwida canal, it passes through the village and can be easily contaminated by parasites. Additionally, the Sherwida canal showed high turbidity, which makes it more liable to microbial and parasitic contamination.

Pollution is more likely to occur in canals that pass by nearby farms, fields, and industrial areas. The percentage of positive samples for parasites in all samples was 71.7% (single and mixed). Parasites were found in several forms: ova, larvae, cysts, and trophozoites. *Cryptosporidium* spp. was the most frequently detected parasite in irrigation water samples followed by *G. duodenalis*. In Egypt, *Cryptosporidium* spp. was the most common protozoan parasite identified in El-Minia Governorate water samples[54]. Moreover, there have been documented high detection rates of these two parasites in water canals in Gharbiya Governorate[55]. Similar results were reported in irrigation waters[51,56]. Water-borne outbreaks caused by *Cryptosporidium* spp. and *G. duodenalis* have been documented not only in Egypt but also worldwide, even in developed countries, *e.g.*, Italy, England, France[14], and North America[57].

Helminths are one of the microbial factors that may be found in water and sludge. Detection and getting rid of helminthic eggs are among the most challenging tasks at the current time[58]. Most STHs are acquired from contact with feces-infected water, soil, or contaminated food, and the use of contaminated water and sludge in agriculture increases the risk of infection. In the present study, helminthic stages such as larvae of Nematode species and eggs of *A. lumbricoides*, *Taenia* spp., *Toxocara* spp., and *Fasciola* spp. were detected respectively in 16.22%, 5.41%, 2.7%, 2.7% and 2.7% of the contaminated samples. While nematode larvae may be parasitic like those of hookworms, or parasitic/free living like those of *S. stercoralis*, there are also those of animal hook worms, and plants. Confirmed differentiation between these forms would require molecular studies. Similar results were found in West Africa and Ethiopia[59,60]. In the current study, the parasitic contamination in summer and spring was higher than in winter and autumn. Similar results were found by Eraky *et al*.[61] who found a significant seasonal variation, with the highest contamination of vegetables in summer and the lowest in winter. It is also reported that the summer exhibited the greatest frequency of parasite infection compared to the winter season[62]. El-Kowrany *et al*.[55] noticed that the summer and spring seasons had higher positive cases of protozoa in water samples than in winter and autumn. More population activities during summer and autumn predispose to more irrigation water contamination. Irrigation with treated and recycled contaminated water may be beneficial in agriculture but harmful to human health due to increasing pathogen concentrations. Etewa *et al*.[63] reported high levels of parasitic contamination of examined vegetables and fruits in Sharkia Governorate possibly from contaminated water used for cultivation. Accordingly, constant monitoring should be applied to irrigation supplies because of the burden of disease brought on by the parasites that are commonly found in water and contaminate ready-to-eat fruit and vegetables.

In conclusion, the recorded parasitic contamination predisposes to a noticeable risk of human infection. Additionally, alterations in the physicochemical parameters of irrigation water can affect food products and provide a suitable environment for parasites. Thus, implementing appropriate routine monitoring of physicochemical parameters and parasitic forms is essential for keeping food products safe, and decreasing health risks.

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