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CONTAMINATION OF SOILS WITH HELMINTHIC EGGS IN SOME DISTRICTS OF DUHOK GOVERNORATE / KURDISTAN REGION-IRAQ

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ABSTRACT

Duhok Governorate, Kurdistan Region consists of many districts, where there is a high distribution of animals, presences of public parks and pastures. The present study was conducted in some of districts (Duhok center, Semel, Amadyia and Sharya) of Duhok Governorate, Kurdistan Region. The current study amid to determine the contamination of soils with helminthic ova and their correlation with the district residents, type of soil and presence of animals (Mainly stray Dogs and Cats).

During this study, 533 soil samples were collected randomly from October 2021 to May 2022. The samples were collected from different places such as dog shelters, general parks, groves, Hospital parks, near pastures, near sewage, private gardens, school parks, and near slaughter houses. The collected samples were tested by flotation technique using saturated zinc sulphate (specific gravity 1.2).

The total rate of soil contamination with helminthic ova in all examined samples was 23.45% (125 / 533). The highest contamination rate with these ova was reported in soil samples examined from Sharya Camp 53.57% (30/56), while the lowest contamination rate was from Semel district 19.22% (49/255). The rates of ova in soils collected from Amadyia and Duhok center were 23.61% (34/144) and 15.38% (12/78), respectively. Regarding to the locations, soil samples examined from rural areas revealed high rate of contamination 29.33% (107/366) as compared with urban areas, in which the rate was 10.78% (18/167). The contamination rates with helminthic ova according to the type of soil, in clay soil was 26.54%, while in silty and sandy soils were 24.39% and 14.96%, respectively.

The contamination rate of soils with these ova was higher in areas populated with animals mainly dogs and cats which was 26.44% (78/295) as compared to areas free from animals 19.75% (47/238) (19. Regarding to different places, the results showed that soils in places close to the sewage were highly contaminated with ova 50.00% (3/6), followed by those near pasture 37.50% (15/40), groves 35.56% (16/35), dog shelters 32.18% (28/87), school Parks 29.41% (10/34), near slaughter houses 27.50% (11/40), public places 21.05% (32/152). On the other hand, the lowest contamination of the soil with these ova was recorded in private gardens 8.26% (10/121), while the soil samples from hospital parks were free from parasitic ova. According to the type of helminths, ova of 6 helminthic genera were reported in all (533) examined soil samples, with *Toxocara* ova being the most prevalent helminths detected in 34 (6.38%), samples, then ova of *Hymenolepis nana* in 32 (6.00%), Taeniid ova in 26 (4.88%), *Ancylostoma* ova in 15 (2.81%), *Ascaris* ova in 12 (2.25%), and *Trichuris* ova in 6 (1.13%).

In conclusion, the soils of some districts were contaminated with different types of helminthic eggs. Therefore, the people of these districts will be at a high risk of acquiring infection with different species of these parasites when they get contacts with the soil.

KEYWORDS: *soils contamination, helminths, zinc sulphate, Duhok districts, Iraq*

INTRODUCTION

Soil is usually contaminated by animals, humans and bird excretes and acts as the major source of soil contamination with pathogens. Human can be infected with different zoonotic diseases that causes health problems. Many zoonotic parasitic diseases that occur when the hosts ingest the infective stage (embryonated ova/ larvae) that passe to the environment (Traversa, 2014). Ova of several parasites are highly resistant to adverse climatic conditions, they can survive in the environment for several months (Mitrea, 2011). Therefore, soil is considered as the most common reservoir for acquiring parasites, which continue their life cycle and survive in the soils until being ingested by a susceptible host. People can be

infected with these parasites through their contact with the contaminated soil during outdoor activities. Soil-transmitted helminths (STHs) refer to a group of parasitic diseases caused by worms, which have a worldwide distribution (Nooraldeen, 2015).

The sources of soil contamination with different species of parasites are occurred by infected animals and humans which can pass the infective stages in the environment through their fecal materials (Traversa *et al.*, 2014). People are infected by ingestion of the infective stages accidently or by direct contact with the soils. The concentration of pets in urban areas is associated with increasing number of free-range animals that contributes in soil contamination in public places (Cassenote *et al.,* 2011). STHs belongs to different species of parasites, especially worms such as *Toxocara* spp., *Ascaris* spp., *Ancylostoma* spp., and *Trichuris* spp. (Traversa *et al.,* 2014). Human infections with dog's worms are the most common zoonotic infections, Pullan *et. al.* (2014) found that over 1.45 billion people were infected with at least one species of intestinal nematodes. Studies conducted on soil samples in different regions of the world have concluded wide range of environmental contamination, especially in public places, like parks and playgrounds for children (Habluetzel *et al.,* 2003; Avcioglu and Burgu, 2008; Bojar and Káapeü, 2012; Stojþeviü *et al.,* 2012; Sprenger *et al*., 2014; Maraghi *et al*., 2014; Otero *et al*., 2014).

The most infected groups for STHs include children of school age between (5 - 15) years, pregnant women and farmers (Mohammed *et al.*, 2016). The most common street or stray animals in Duhok city are cats and dogs which can excrete in public places leading to soil contamination. Human can acquire infection with parasites during contact with contaminated the soil when they have gone to public gardens (Yaro *et al.,* 2018). The soil contamination with parasites in public areas has been recorded as a source of infection the parasites in the population, especially among small children (Martínez-Moreno *et al.*, 2007; Marques *et al*., 2012). Furthermore, few investigators in Iraq and Kurdistan Region have performed such studies, in Erbil (Nooraldeen, 2015), and in Baghdad (Musa, 2017).

To the best of our knowledge, there is no studies dealing with the extent of soil contamination with helminths in Duhok Governorate except a study done by Golik and Al-Saeed (2019) in the Amadyia district that concentrated on the soil contamination with *Toxocara* eggs and another study in Zakho district involved soil contamination with infected stray dog's feces and reported many helminthic eggs and *Strongyloides* larvae (Issa *et al*., 2022). The current study amid to determine the contamination of soils with helminthic parasites and their relation with places, residency, types of soils and presence of animals (Mainly stray Dogs and Cats) in some Districts of Duhok Governorate, Kurdistan Region/Iraq.

MATERIALS AND METHODS

Area of the Study

Duhok Governorate - Kurdistan Region is located in the North part of Iraq. In Duhok governorate the climate has a hot-summer and cool rainy winters.

Collocation of Soil Samples

In the current study, 533 samples of soils were randomly collected from some districts of Duhok Governorate during the period from October 2021 to May 2022. The soil samples were collected at a depth of 5-10 cm, about 20 g of the soil was taken for each sample without vegetation, and placed in a sealed and labelled nylon bag, then transported to the parasitology laboratory, at the College of Medicine, Duhok University. Soil samples were examined as soon as possible but sometimes were kept in a refrigerator at 4 ^{o}C for few hours until examined. All samples were examined by both saturated Zinc sulphate ($ZnSO_4$) flotation method with specific gravity 1.2 and saline sedimentation method (Mandarino -Pereira *et al.,* 2010; Mitrea,2011).

Statistical Analysis of the Data

The information of the characteristic criteria was clarified in number and percentage. The rate of parasite ova and their types among different samples were determined in dividing the number of positive samples on the number of collected samples The association of parasite rates and their types with general information were tested in Pearson's chi-squared test. The difference of significant level was estimated at a *P*-value <0.05. The statistical tests were designed in JMP pro-14.3.0. The figures were created using the Microsoft excel 2013.

RESULTS

Table (1): shows the general characteristic criteria of all soil samples collected during the present study (n = 533).

General characteristics	Statistics	
	Number	**Percentage**
Districts		
Amadyia	144	27.02
Sharya (Camp)	56	10.51
Duhok Center	78	14.63
Semel	255	47.84
Residency		
Rural	366	68.67
Urban	167	31.33
Soil type		
Clay	324	60.79
Sand	127	23.83
Silty	82	15.39
Animal presence		
No	238	44.65
Yes	295	55.35
Place type		
Dog's shelters	87	16.32
General place	152	28.52
Groves	45	8.44
Hospital Park	8	1.50
Near-pasture	40	7.50
Near-sewage	6	1.13
private garden	121	22.70
School Parks	34	6.38
Slaughter house	40	7.50

The total contamination rate with parasites of all examined soil samples was 23.45% (125 / 533), and this rate of contamination among general characteristics were listed in (Table 2). The highest contamination rate 53.57% (30/56) with parasites ova was reported in soil samples that examined from Sharya Camp, while the lowest contamination rate was19.22% (49/255) in Semel district. The presence of parasites ova in the soils examined from Amadyia and Duhok center were 23.61% (34 / 144) and 15.38% (12 /78), respectively. The statistical analysis of soils contamination with parasites ova between different places were highly significant ($P< 0.0001$).

Regarding the residency, soil samples examined from rural areas revealed high rate of contamination which was 29.23% (107 / 366) as compared with urban areas 10.78% (18/167). Statistically the difference between both areas was highly significant ($P < 0.0001$).

The contamination of soils according to the type of soil, clay soil showed the highest rate of contamination, followed by silty and then sandy, at rates of 26.54%, 24.39% and 14.96%, respectively. Statistically the differences between the three soil types were significant ($P < 0.0323$).

It is obvious from Table (2) that the contamination of soils with helminthic ova was higher in areas populated with animals mainly stray Dogs and Cats at a rate of 26.44% (78/295), when compared with areas free from animals 19.75% (47/238). Statistically the difference between areas were non-significant ($P = 0.0698$).

Regarding to the type of places, the results showed that the 50% (3/6) of the soil in places near the sewage were contaminated with ova,

followed by that near pasture in which 37.50% (15/40), then the rate declined with the lowest rate 8.26% (10/121) in private parks, while the soil of hospital parks was free from helminthic ova as illustrated in table 2. Statistical analysis showed the presence of highly significant differences ($P< 0.0001$) in comparison with different places.

Table (2): Frequency of soil contamination with helminthic ova in relation to Different criteria (n = 533).

General Characteristics	No. examined	No. and % of Contaminated soil samples with helminthic ova		*P*-value
		Non-contaminated (408 / 76.55%)	**Contaminated (125 / 23.45%)**	
Districts				**< 0.0001**
Amadyia	144	110 (76.39)	34 (23.61)	
Sharya (Camp)	56	26 (46.43)	30 (53.57)	
Duhok Center	78	66 (84.62)	12 (15.38)	
Semel	255	206 (80.78)	49 (19.22)	
Residency				**< 0.0001**
Rural	366	259 (70.77)	107 (29.23)	
Urban	167	149 (89.22)	18 (10.78)	
Soil Type				**< 0.0323**
Clay	324	238 (73.46)	86 (26.54)	
Sandy	127	108 (85.04)	19 (14.96)	
Silty	82	62 (75.61)	20 (24.39)	
Animal presence				0.0698
No	238	191 (80.25)	47 (19.75)	
Yes	295	217 (73.56)	78 (26.44)	
Place type				**< 0.0001**
Dog's shelters	87	59 (67.82)	28 (32.18)	
General place	152	120 (78.95)	32 (21.05)	
Groves	45	29 (64.44)	16 (35.56)	
Hospital Park	8	8 (100.00)	0 (0.00)	
Near-pasture	40	25 (62.50)	15 (37.50)	
Near-sewage	6	3 (50.00)	3 (50.00)	
Private garden	121	111 (91.74)	10 (8.26)	
School Park	34	24 (70.59)	10 (29.41)	
Slaughter house	40	29 (72.50)	11 (27.50)	
Person chi-squared test				

According to the types of helminths, ova of 6 types were reported from the total number of examined soil samples (533), *Toxocara* ova were the most common helminths found in 6.38% (34), then ova of *Hymenolepis nana* in 6% (32), Taeniid ova in 4.88% (26), *Ancylostoma* ova in 2.81% (15), *Ascaris* ova in 2.25%), and *Trichuris* ova in 1.13% (6) as listed in Table (3).

Table (3): Total numbers and percentages of soil contamination with the eggs of helminthic genera **(n = 533)**

Type of helminths	No. of contaminated soil samples	Percentage
Toxocara	34	6.38
Hymenolepis nana	32	6.00
Taenia	26	4.88
Ancylostoma	15	2.81
Ascaris	12	2.25
Trichuris	6	1.13
Total	125	23.45

Regarding to the helminthic types isolated from contamination soil samples collected from different districts in Duhok Governorate (Table 4), in Amadyia, 5 types of helminthic ova were recorded, with the highest rate of *Toxocara* ova which were found at 8.33% of the samples, followed by *Hymenolepis nana* in 6.94%, *Ascaris* in 2.78%, *Trichuris* in 0.69%. Regarding to soil samples examined from the Camp of Sharya district, the results revealed that the highest rate of contamination was with *Toxocara* at 16.07%, followed by *Ancylostoma* and *Hymenolepis nana* at the same rate of 12.5% for each of them, while *Trichuris* and *Ascaris* were recorded in 3.57%, 1.79%, respectively.

In Duhok Center, the highest rate was recorded with *Hymenolepis nan* and Taeniid ova in 5.13% for both types, followed by *Ancylostoma* and *Toxocara* in 2.56%, 1.28%, respectively. In Semel District, *Toxocara, Hymenolepis nana* and Taeniid were reported at highest rate of contamination (4.71%, 4.31%, 4.31%), respectively, followed by *Ancylostoma* and *Ascaris* both at the same rate (2.35%), while the lowest rate was with *Trichuris* 1.18%. The statistical analysis showed the presence of highly significant differences ($P<$ 0.0001) different districts.

Table (4): Contamination of Soils with Helminthes types in relation to Districts - Duhok Governorate.

	No. examined	**Contaminated with Helminthes types**						***P*-value**
		Ancylostoma	***Ascaris***	***Hymenolepis nana***	***Taenia***	***Toxocara***	***Trichuris***	
Districts								**< 0.0001**
Amadyia	144	0 (0.00)	4 (2.78)	10 (6.94)	7 (4.86)	12 (8.33)	1 (0.69)	
Sharya (Camp)	56	7 (12.50)	1 (1.79)	7 (12.50)	4 (7.14)	9 (16.07)	2 (3.57)	
Duhok Center	78	2 (2.56)	1 (1.28)	4 (5.13)	4 (5.13)	1 (1.28)	0 (0.00)	
Semel	255	6 (2.35)	6 (2.35)	11 (4.31)	11 (4.31)	12 (4.71)	3 (1.18)	
Person chi-squared test								

It was clear from (Table 5), that rural areas recorded the highest contamination rates of all types of helminthic ova when compared with urban areas. Ova of *Toxocara*, *Hymenolepis nana* and Taeniid were found in 8.74% (32), 6.83% (25), and 5.74% (21) samples, respectively from rural areas. The lowest rates were with *Ancylostoma* 3.55% (13), *Ascaris* 2.73% (10), and *Trichuris* 1.64% (6). Regarding to the soil samples examined from urban areas, the results reveal that the highest rate was found in 4.19% (7), the recorded species included *Hymenolepis nana*, and Taeniid 2.99% (5), while the rates of contamination were the same with *Ancylostoma, Ascaris* and *Toxocara* in 1.20% (2). *Trichuris* eggs were not recorded in urban areas soil samples. The statistical analysis showed the presence of highly significant differences (< 0.0004) in relation to residency.

Table (5): Contamination of soils with helminths types in relation to residency-Duhok Governorate (n = 533).

	No. examined	Contaminated with helminthic ova						*P*-value
		Ancylostoma No. %	*Ascaris* No %	*Hymenolepis nana* No %	Taeniid No %	*Toxocara* No. %	*Trichuris* No. %	
Residency								**< 0.0004**
Rural	366	13 (3.55)	10 (2.73)	25 (6.83)	21 (5.74)	32 (8.74)	6 (1.64)	
Urban	167	2 (1.20)	2 (1.20)	7 (4.19)	5 (2.99)	2 (1.20)	0 (0.00)	
Pearson chi-squared test								

The results of contaminated soil samples with helminthic ova according to types of soils were listed in Table (6). The highest rates in clay soil were with *Toxocara* 7.41% (24), *Hymenolepis nana* 6.79% (22) and Taeniid 5.56% (18), while the lowest rates were with *Ancylostoma* 3.09% (10), *Ascaris* 2.47% (8) and *Trichuris* 1.23% (4). Regarding to sandy soil, *Hymenolepis nana* 4.72% (6), Taeniid 3.15% (4) *Ancylostoma* 2.36% (3), *Toxocara* 2.36% (3), *Ascaris* 1.57% (2), and in one sample 0.79% (1) *Trichuris* was observed.

In silty soil, the highest rates of contamination were with *Toxocara* 8.54% (7) followed by *Hymenolepis nana* 4.88% (4) and *Taenia* 4.88% (4), while the lowest rates were with *Ancylostoma* 2.44% (2), *Ascaris* 2.44% (2) and *Trichuris* 1.22% (1.0). Statistical analysis revealed non-significant differences (*P*=0.7349) between the rate of contamination in different soils types.

Table (6): Relationship between rate of contamination of helminthic ova with the type of the soil, in Duhok Governorate (n = 533).

	No. examined	Contamination with type of helminthic eggs						*P*-value
		Ancylostoma No. %	*Ascaris* No. %	*Hymenolepis nana* No. %	Taeniid No. %	*Toxocara* No. %	*Trichuris* No. %	
Soil Type								0.7349
Clay	324	10 (3.09)	8 (2.47)	22 (6.79)	18 (5.56)	24 (7.41)	4 (1.23)	
Sandy	127	3 (2.36)	2 (1.57)	6 (4.72)	4 (3.15)	3 (2.36)	1 (0.79)	
Silty	82	2 (2.44)	2 (2.44)	4 (4.88)	4 (4.88)	7 (8.54)	1 (1.22)	
Pearson chi-squared test								

Regarding to the relation between contamination of soils and the presence of animals mainly dogs and cats (Table 7), the results showed that the highest rates were with *Toxocara* 7.12% (21), *Hymenolepis nana* 6.44% (19) and Taeniid 5.76% (17), while the lowest rates were with *Ancylostoma* 3,05% (9), *Ascaris* 2.71% (8) and *Trichuris* 1.36% (4). Furthermore, the absent of animals from some areas didn't affect the rate and the type of helminths that contaminate the soil. Because all the six types of helminths were reported: *Hymenolepis nana* and *Toxocara* were found at the same rates 5.46% (13), Taeniid 3.78% (9), *Ancylostoma* 2.52% (6), *Ascaris* 1.68% (4) and *Trichuris* 0.84% (2). Statistically the presence or absence of animals was non-significant (*P*=0.7210).

Table (7): Contamination of Soils with Helminthes type in relation to presence of animals - Duhok Governorate (n = 533).

	Contamination with Helminthic ova						*P*-value
	Ancylostoma **No. %**	***Ascaris*** **No. %**	***Hymenolepis nana*** **No. %**	**Taeniid No. %**	***Toxocara*** **No. %**	***Trichuris*** **No. %**	
Animals presence							0.7210
No	6 (2.52)	4 (1.68)	13 (5.46)	9 (3.78)	13 (5.46)	2 (0.84)	
Yes	9 (3.05)	8 (2.71)	19 (6.44)	17 (5.76)	21 (7.12)	4 (1.36)	

Pearson chi-squared test

The results of soils contamination with ova of helminths in relation to places (Table 8), ova of *Toxocara* were the most frequent near sewage, and near pastures at rates of 50.0% (3/6), 17.50% (7/40) and 14.94% (13/87), respectively. The lowest rates were found in dog's shelters, groves, general places and near slaughter houses 11.11% (5/45), 3.29% (5/152) and 2.50% (1/40) respectively. *Toxocara* were not recorded in soil samples collected from Hospitals Park, Private gardens and Park of schools. Ova of *Hymenolepis nana* were reported from school Parks at 11.76% (4/34), Groves in 11.11% (5/45), general places in 10.53% (16/152), near pastures in 10.00% (4/40), and private gardens in 3/121 (2.48%), while not reported in dog's shelters, Hospital parks, near sewage and slaughter houses. Taeniid ova were found at the highest rates in soils around slaughter house in 15.0% (6/40) followed by groves in 8.89% (4/45), dog's shelters in 6.90% (6/87), school parks in 5.88% (2/34), near pastures in5.00% (2/40), and Private gardens in 3.31% (4/121). On the other hand, the lowest rate was reported from general places in 1.32% (2/152) and not found in Hospital parks and near the sewage.

Ova of *Ancylostoma* were found with the highest rate in School parks 8.82% (3 /34) and dog's shelters 4.60% (4/87), followed by general places 3.95% (6 /152) and near slaughter house 2.50% (1/ 40). Hookworms have not been reported from Groves, Hospital Parks, near-pasture, and near-sewage. Regarding to the ova of *Ascaris*, the highest rates of soils contamination were found near slaughter house7.50% (3/40) and near pastures 5.00% (2/40), and dog's shelters 3.45% (3/87), while the lowest rates were found in groves, private gardens and general places in 2.22% (1/45), 1.65% (2/121) and 0.66% (1/152), respectively. They were not reported from Hospital Parks, near sewage and School parks. Ova of *Trichuris* were not recorded in soil examined from Hospital Parks, near-pasture, near-sewage, private gardens and around slaughter houses. This worm was found in school parks 2.94% (1/34), dog's shelters 2.30% (2/87), groves 2.22% (1/45) and general places 1.32% (2/15). The statistical analysis revealed highly significant differences ($P<$ 0.0001) in comparison with different places.

Table (8): Contamination of soils with helminths type in relation to places in Duhok Governorate **(n = 533).**

Place type	Contamination with Helminthic ova						***P*-value**
	Ancylostoma **No. %**	***Ascaris*** **No. %**	***Hymenolepis nana*** **No. %**	**Taeniid No. %**	***Toxocara*** **No. %**	***Trichuris*** **No. %**	
							< 0.0001
Dog's shelters	4 (4.60)	3 (3.45)	0 (0.00)	6 (6.90)	13 (14.94)	2 (2.30)	
General places	6 (3.95)	1 (0.66)	16 (10.53)	2 (1.32)	5 (3.29)	2 (1.32)	
Groves	0 (0.00)	1 (2.22)	5 (11.11)	4 (8.89)	5 (11.11)	1 (2.22)	
Hospital Parks	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
Near-pasture	0 (0.00)	2 (5.00)	4 (10.00)	2 (5.00)	7 (17.50)	0 (0.00)	
Near-sewage	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	3 (50.00)	0 (0.00)	
private gardens	1 (0.83)	2 (1.65)	3 (2.48)	4 (3.31)	0 (0.00)	0 (0.00)	
School Parks	3 (8.82)	0 (0.00)	4 (11.76)	2 (5.88)	0 (0.00)	1 (2.94)	
Slaughter house	1 (2.50)	3 (7.50)	0 (0.00)	6 (15.00)	1 (2.50)	0 (0.00)	

Person chi-squared test

DISCUSSION

Soil contamination with helminthic ova is a direct indicator of risk for the transmission of these parasites to humans or animals. In the current study, the overall contamination rate of soil specimens was 23.45 % (125 /533) out of the examined specimens, and this rate is an indicative of public health risk posed by these ova. This study is consistent with other studies worldwide which reported higher rates of soil contamination with helminthic ova. In Sudan, Nigeria, and Ethiopia rates of 67%, 68.1%; 50.6%, and 35%, respectively, were reported (Mohammed *et al*., 2016; Hassan *et al*. 2017; Badaki *et al*., 2018; Tadege *et al*., 2022). On the other hand, a lower rate of 17.6% of STH was reported in south Cameroon by Joel *et al*. (2021).

In the present study the highest total rate (6.38%) was with *Toxocara* ova, which were the most frequently found near sewage, and near pastures of 50% (3/6), 17.50% (7/40) and 14.94% (13/87), respectively. While the lowest rates were recorded in dog's shelters, groves, general places and near slaughter houses, at rates of 11.11% (5/45), 3.29% (5/152) and 2.50% (1/40) respectively. Soil specimens taken from hospital parks, private gardens, and school parks were free from *Toxocara* ova.

Variable rates of soil contamination with *Toxocara* ova were reported mainly from Erbil city by Molan and Faraj (1989); Hussein, 1997; Faraj (2000); Ahmed (2006); Nooraldeen (2015) which were: 13.6 %, 14%, 18.1%, 16%, and 50 %, respectively. As regard to other parts of Iraq, In Basra, Mahdi and Ali (1993) recorded a rate of 12.2% of soil contamination with *Toxocara* ova. In Alnassiriyah city center, southern part of Iraq, Al-Kassar (2009) recorded a rate of 16.43% with *Toxocara* ova in soils of public places and children play grounds.

In countries neighboring Iraq, also variable rates of soil contamination with *Toxocara* ova were reported, in northern and central areas of Jordan, a rate of 15.45% was found in soil specimens collected from school playgrounds and public places (Abo-Shehada, 1989). In Riyadh, Saudi Arabia, Al-Megrin (2010), reported 20% of *Toxocara* ova in leafy vegetables. In Turkey Ge and Ge (2000) stated that 8.25% - 60.9% of public parks were contaminated with *Toxocara* ova. In Iran, Motazedian *et al*. (2006) reported that 6.3% of public places in Shiraz city was contaminated with *Toxocara* ova. In Iran also, much higher rates of soil contamination with ova in public places reaching to 22.2% (in Khorram) and 79.3% (In Tehran) were reported by Zibaei *et al.*, (2010) and Tayalla *et al*. (2012), respectively. In other countries, in Europe, Habluetzel *et al.,* (2003) reported 24% of soil contamination with *Toxocara* ova in Italy, in Poland, 18.6%, Bojar and Káapeü (2012) and 10.6%, Blaszkowska *et al.* (2013) of soil were contaminated with *Toxocara* ova. In Portugal very high prevalence of *Toxocara* ova reaching 63.3% was reported by Otero *et al.* (2014), respectively. In Brazil, several studies were conducted, and reported soil contamination rate with *Toxocara* ova at 22.4% (Mandarino-Pereira *et al.,* 2010), 30.2% (Cassenote *et al.*, 2011) 36% (Sprenger *et al.,* 2014), 44%, De -Moura *et al.,* (2013) and 78.6%, Marchioro *et al.,* (2013).

The variation between the results of all of these studies may be attributed to a wide range of factors, such as climatic conditions, dogs' population and their spreading, soil type, number of soil samples examined, behavioral habits, socioeconomic status, time of sampling, method of storing soil samples, and techniques used for sample analysis (Oyebamiji and Hassan, 2021)

The public schools that were included in the current study were without fences, thus dogs can enter their yards freely without any obstacles, which might be infected with *Toxocara* worms. During sample collection, children were seen playing in the soil with their bare hands and feet, even not wearing shoes or slipper, thus increasing the risk of acquiring *Toxocara* infection.

In the present study, other helminthic ova were reported including, *Hymenolepis*

nan, *Trichuris* spp., *Ancylostoma* spp., *Ascaris* spp. and Taeniid ova, at rates of 6.00%, 1.13%, 2.81%, 2.25%, and 4.88%, respectively. All of these helminthic ova were recovered from soils in many studies. In Baghdad, Fathailah, (1988) reported the prevalence of ova of some helminths as 22% *Ascaris*, 26% *Hymenolepis nana*, 12.57% *Ancylostoma* 14% *Hymenolepis diminuta*. In Baghdad, also, Guirges and Al-Mofti (2005) reported the prevalence of helminthic ova as 20% *Hymenolepis nana*, 25% Ascaris, 21%, *Hymenolepis diminuta*, 19% of *Ancylostoma* and 15% *Trichuris*. In Erbil city, Saida and Nooraldeen (2014) reported the prevalence of some helminthic ova as: *Echinococcus granulosus* 22.4%, *Ascaris* 18.3%, *Hymenolepis nana* 10.2%, *Hymenolepis diminuta* 4.0%, *Trichostrongylus* 8.1%, *Enterobius vermicularis* 4.0% and *Dipylidium caninum* 6.1%. In another study in Erbil city conducted by Nooraldeen (2015), he found ova of *Hymenolepis diminuta* in 75%, *Ascaris* in 33.3%, *Taenia* in 25%, *Ancylostoma* in 25% and 16.7% for *Trichuris.*

It is not possible to make an accurate comparison between the results of all of these studies because the recovery of parasitic ova from various localities is highly variable depending on environmental factor, soil types, choosing sampling sites, the number or population of animals defecating in the sampled area and the methods used for soil analysis. The increased prevalence of some of these helminthic ova in the soil might be due to using humans and animals waste for fertilizing the farms as they have been widely used in some countries including Iraq. In addition to poor environmental cleanliness and sanitation in particular the existence of a large number of stray dogs that can lead to soil contamination (Ziegelbauer *et al*., 2012; Truscott *et al*., 2014). Other reason for environmental contamination with these ova is the tendency of stray dogs to remain in humid areas and such areas are favorable for the survival of helminthic eggs which can remain alive for few months to years (Murray *et al*., 2015). While under harsh environmental conditions and direct sun light they will be destroyed within short periods, therefore, favorable temperature, humidity, rain, soil pH, and soil type are significant factors in determining the viability and development of ova (Brooker *et al*., 2006). Thus, the climatic variations during the year or from one place to another may affect the rate of soil contamination throughout the months of the year in various locations or even in the same location. Winter and Spring seasons in Kurdistan region and rest parts of Iraq have fluctuated temperatures and rain fall, during these seasons the highest rates of contamination occurs in the soil.

CONCLUSIONS

Soil transmitted helminths are still highly prevalent in different districts of Duhok governorate. This could be attributed to presence of a large number of stray dogs, in addition to poor environmental sanitation, poor personal hygiene due to several factors such as poor or adequate sanitary facilities, low level of health education among the community, and other associated risk factors in the studied locations. Therefore, in order to combat the transmission and re-infection among the population its preferred to disseminate the preventive programs among the community and to control the population of stray dogs or use deworming treatments especially for those dogs which accompany sheep herds.

Declarations

This study is an original one that has never been submitted, accepted or published before in any journal.

Data Availability Statement:

All data described in this manuscript are freely available.

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Conflicts of Interest:

The authors declare that there is no any conflict of interest in this study.

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