Geohelminths distribution as affected by soil properties, physicochemical factors and climate in Sharkya governorate Egypt

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Abstract Soil-transmitted helminths are mainly a group of parasitic nematodes causing human infection through contact with parasite eggs or larvae; they survive in the warm and moist soil of the tropical and subtropical countries. This study was carried out in Sharkya governorate from October, 2011 to October, 2013, to correlate between the prevalence and distribution of these parasites in the soil and the physicochemical factors affecting the examined samples of the soil. One hundred and twenty samples of different types of soil (clay, silt, sand) from different localities were collected and examined. Diagnosis of geohelminths was confirmed by the recovery of their eggs and larvae with other protozoa by different parasitological methods. The modified baermann method was found to be more efficient in detection of geohelminths larvae than charcoal culture method. Among the examined sites geohelminths were much more numerous in the soil of rural areas especially in the spring and summer seasons, while the contamination of canal banks by geohelminths was the worst (80 %). An insignificant correlation was reported between the soil texture and the number of positive samples in the examined areas while the relationship was directly proportional among (moisture, PH, organic). It

appeared that the most common geohelminthic stage was *Toxocara* spp. eggs besides other types of protozoa especially *Balantidium coli* cysts. This suggests that factors other than soil texture are important in the prevalence of geohelminths in the soil e.g. temperature, moisture, PH and organic matter. So, to change some of these factors in a trial to control geoparasites transmission but with keeping the environment should be tried. These results also open the way to further studies to highlight the mutual affection between inhabitants of these sites and the prevalence of these geoparasites.

Keywords Geohelminths · Soil · Temperature · Moisture · Organic matter · PH · *Strongyloides* · *Toxocara* · *Ascaris* · Hookworms · Sharkya · Egypt

Introduction

Soil-transmitted helminths (STH) are mainly a group of parasitic nematodes causing human infection through contact with parasite eggs or larvae; they survive in the warm and moist soil of the tropical and subtropical countries (Hong et al. 2006). In the life cycle of these helminths, the soil receives (by faecal contamination) stages which are not infective, the soil provides conditions that under which development to be the infective stage can take place, the soil gives protection for the infective stage for a period, during which it may be brought into contact with a susceptible individual by the mouth or the skin (Bethony et al. 2003).

More than a billion people are infected with at least one species of particular worldwide important roundworms which are (*Ascaris lumbricoides*), whipworms (*Trichuris trichiura*), *Strongyloides stercoralis* and hookworms

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(*Ancylostoma duodenale*) (Hotez et al. 2006). They are considered together because it is common for a single individual, especially a child living in a less developed country to be chronically infected by more than one of these worms (Kunwar et al. 2006).

Ascaris and *Trichuris* commonly occur both in urban environments, especially urban slums also in rural areas. In some instances the prevalence of *Ascaris* infection is actually greater in urban environments. The social and environmental conditions in the unplanned slums of developing countries are ideal for the persistence of *A. lumbricoides* and *T. trichiura*. (Phiri et al. 2000). In contrast, high rates of hookworm infection are typically restricted to areas where rural poverty predominates. *Ascaris* and *Trichuris* eggs develop best in less permeable clay soils; the survivability is increasing with soil depth. Clay soils are believed to prevent egg dispersal by water. The vulnerability of *Ascaris* eggs to direct sunlight may account for part of this observation. Unlike *Ascaris* and *Trichuris* eggs, hookworm eggs hatch in the soil and give rise to first-stage larvae, which molt to infective larval stages only under precise conditions. Egg development in the soil is dependent upon a number of factors including temperature (optimal development at 20–30 °C) and adequate shade and moisture (Crompton 2001). Lilley et al. (1997) reported that the additional presence of silt that contains microscopic and barely visible particles provides optimal conditions. Such soil is sometimes known as ‘sandy loam’. Changing environmental conditions, specifically deforestation and subsequent silting of local rivers may cause deposition of sandy loam topsoils and increasing soil moisture, this might promote the emergence of endemic hookworm.

Umar and Bassey (2010) studied the survival of free living form of *Strongyloides stercoralis* which is favored in damp, sandy or friable soil with decaying vegetation and contaminated with human excreta. Moreover, the very low and optimal conditions as warmth, oxygen, light and moisture are required for survival of its free living larvae.

The soil also acts as an important vehicle of transmission of *Toxocara canis* and *Toxocara cati* eggs. These eggs accumulate in the deeper layers of the soil and they develop to the infective stage within few weeks at summer, they remain in the soil for many months depending upon soil type and climatic conditions as the moisture retaining soil enhanced development of *Toxocara* eggs, while sunlight or desiccation are responsible for their integration (Beaver et al. 1984).

The existence of viable geohelminth eggs in the superficial layer of soil presents potential public hazards; especially these eggs extremely resist adverse weather and chemical agents. Thus, soil contamination seems to be the most direct indicator of STH infection among human

population, for this reason studies have been carried out in recent years to determine the prevalence of geohelminths eggs in the parks, playgrounds and beaches (Błaszowska et al. 2011)

Certain occupations that increase contact with soil contaminated with human waste, they may include farming, gardening, and duck hunting and coal mining depending local practices, increase the risk of infection (WHO 1964).

Fundamentally, the endemicity of STH depends upon the presence of infected individuals, habitual or continual faecal contamination of the soil and a favourable soil environment (physical and chemical factors) for the development of infective stages and frequent contact between infective soil and uninfected individuals. So, the prevalence of a parasitic infection is a consequence of both natural and cultural factors (Stephensom et al. 2000). Umar and Bassey (2010) recorded that, due to limited resources in most developing countries, it is difficult to prioritize STH control and other health problems a high priority. This seems to be the true reason for sustained prevalence and worm burdens of STH in developing countries.

The present study was to determine the prevalence of geohelminths in Sharkya governorate and its relation to the type of soil and its properties either physical, such as soil moisture, texture and aeration or the chemical factors such as the soil content of the organic matter and also the PH, as well as to develop effective control schemes of infection transmission through studying the physicochemical characteristic of the soil which supply the requirements essential for the development of the infective stages of STH, without altering the environmental conditions.

Materials and methods

Study type

This study was designed as a cross sectional prevalence study. The study was conducted in from October 2011 to October 2013. The practical work was done at the laboratories of the parasitology department of the faculty of medicine and the central lab of the soil, feed and feed stuff of Zagazig University, Zagazig, Egypt.

Study area

The current study is considered the first one in Sharkya governorate, it is one of the governorates of Egypt with total area 4,180 km² and about 5,340,058 inhabitants and it is located in the northeastern part of the country. It is the eastern governorate of the Nile river delta i.e. Lower Egypt, it touches the Mediterranean Sea at the west of Suez Canal. It includes a part of the large lake Manzala, a

brackish coastal lagoon. Sharkyia is located at latitude 30.7°N and longitude 31.63°E with four distinct seasons. The climate is hot and dry. The average temperature is 18 °C in winter and 42 °C in summer with high humidity. Sharkyia governorate lies along the river system where Muis canal runs along it. The soil of this governorate is variant (clay, silt, sandy) but most of it is clay, moist with decaying vegetation and contaminated with human excreta resulting from indiscriminate defecation and fecal disposal. Considering these factors, the environment is suitable for both the free living and parasitic mode of life of geohelminths. The study was carried out on different sites in Sharkyia governorate including Belbis, Banyuos, Kafer el hamam, Kafer saker, Kafer zagazig el bahre, El-kanyat, Abo hammad, Abassa canal, Mashtoul el kade, Zankalon, all over the year from October 2011 to October 2013. The samples of the different types of the soil were taken from different locations as: playgrounds, irrigation canal banks and around schools (Akl and Abdel-Aziz 2008) (Fig. 1).

Collection of soil samples

A total 120 samples (about 500 g each) were collected from different types of soil (clay, sandy and silt) all over the year from the same localities. They are taken from a depth about 50 cm from the surface and weighing approximately 500 g. They are put into closed plastic bags labeled by numbers, transferred to laboratories under strict measures in a car (to avoid any extra contamination) where parasitological and physical and chemical studies were performed on them.

Fig. 1 Sharkyia governorate map

Parasitological study

Detection of different parasitic stages

The collected samples were examined in the laboratory after sieving through a 4 mm mesh sieve by the following methods

- Eggs (ova) or larvae of geohelminths were recovered by making and examining three slides from each soil sample by these methods:
 - Direct wet mount method (World Health Organization 1983)
 - Zinc sulphate flotation method (Dada 1979)

The recovered parasitic stages were counted, the average was taken and the results were recorded.

- Detection of larvae:
 - Modified Baermann technique: (Graeff-Teixeira et al. 1997)
 - Charcoal culture: (Beaver et al. 1984)

Modified Wisconsin Sugar Flotation Method (Matsuo and Kamiya 2005)

Physic-chemical study of the soil:

- *Detection of the soil moisture* to detect the water content of the soil by (105 °C method) (Gardner 1986)
- *Detection of soil texture* (Bouyoucos 1962) to detect the grain size composition using sieving and aerometric technique. The size of gravel (>2.0 mm), sand (2.0–0.11 mm), silt (0.10–0.02 mm) and clay (<0.02 mm) was established.
- *Detection of PH of the soil* by (PH method) (Conkling and Blanchar 1988)
- *Detection of organic matter* by (Titration method). (Christensen 2001)

Statistical methods

All data were subjected to statistical analysis using spss win statistical package version 20. The Chi squared (X^2) or Fisher exact test was used when appropriate. Data were presented as median and range and analyzed by Mann–Whitney test.

Discussion

Soil transmitted parasites have soil as a common medium for development of immature eggs and early stages of larvae, also, soil acts as a reservoir for infective eggs and

larvae of helminthes, cyst and oocysts of protozoa (Hanafi et al. 1987).

This study has shown a high prevalence of geohelminths in rural areas than urban areas. This rural–urban dichotomy can be partly understood by the social and environmental conditions in the unplanned slums of developing countries. The prevalence is directly related with the degree of contamination by faeces either as a night- soil or as irrigation sewage with accumulation of organic debris discharged from surrounding houses (Beaver 1952).

In Egypt, in Dakhlia Governorate, Hanafi et al. (1987) identified helminth eggs in 1031 out of 1,114 (92, 5 %) soil samples which were collected from four villages in Talkha, Da-kahlia. El-Beshbishi et al. (2005) detected also geoparasites in 571 out of 1,070 (53, 4 %) soil samples collected from four agricultural villages in the same governorate. Regarding the environmental conditions Sharkyia governorate is mostly similar to Dakahlia governorate.

In the current work, *Toxocara* spp. eggs were the most widely distributed geoparasites. This is attributed to the presence large number of stray dogs and cats in the public places especially in rural areas. Moreover, these eggs could have been carried from the livestock on the farmers' shoes from place to place (Kozakiewicz 1980) (Table 1).

Moreover, In Egypt, Khalil et al. (1978) examined soil samples collected from other different governorates and they reported the following rates of *Toxocara* contaminations: 12.5, 11.5, 10 and 7.5 % in Giza, Cairo, Dakahlia and Qualyobia respectively.

Seasonal and climatic conditions are important factors affecting the prevalence of geohelminths (Schad et al. 1973). This finding was proved by the current study that

under natural conditions the occurrence of geohelminths in spring and summer was very active. It was recognized that drying by sunlight and washing the eggs to the deeper layers with rain water are the main factors which cause self purification of soil (Mizgajska 1993). Moreover, Mizgajska (1997) proved that under natural conditions geohelminths are very active in spring and autumn. Many researchers have also studied the influence of the seasons on the prevalence of geohelminths especially *Toxocara* spp. eggs. Shimizu (1993) recorded the presence of *Toxocara* eggs in public parks of Tokushima (Japan) in a higher frequency during spring and early summer than that in the winter. This is associated with the presence of greater number of wandering stray puppies during spring (Avcioglu and Burgu 2008).

Blaszkowska et al. (2013) reported that, more helminth eggs were detected from samples collected during April–May than October–November. In contrast, Stojcevic et al. (2010) reported that *Toxocara* eggs were lower in the summer than winter in recreation areas in Pula (Croatia).

Although, the seasonality of factors like rainfall, temperature, humidity is important in the transmission of geohelminths. These factors may be relatively constant under tropical conditions. Flies that perch on the fecal materials deposited on the contaminated soils help to spread eggs of *Ascaris*, *Trichuris* and other helminth eggs (Nwosu and Anya 1980).

Geohelminths eggs transmission could be considerably supported as they were carried with residues to the surface of the soil. This was confirmed by an early result obtained under experimental conditions for *Ascaris* and *Taenia* eggs (Lonc 1980).

Table 1 The distribution of geohelminths in the rural and urban areas of Sharkyia governorate all over the year

Parasite	Urban		P_1 value	Rural		P_2 value	P_3 value
	A	B		A	B		
<i>Strongyloides</i> spp.	2	1	0.1	5	2	0.69	0.14
<i>Toxocara</i> spp. eggs	4	1	0.53	8	2	0.86	0.1
<i>Ascaris</i> spp. eggs	1	0	0.47	4	1	0.66	0.18
<i>Taenia</i> spp. eggs	0	0	1.0	1	0	0.36	1.0
<i>Ancylostoma</i> spp. eggs	0	0	1.0	2	0	0.74	0.48
<i>Ancylostoma</i> spp. larvae	0	0	1.0	1	0	0.36	1.0
<i>Trichuris</i> spp. eggs	0	0	1.0	0	0	1.0	1.0
<i>Balantidium</i> spp.	0	0	1.0	2	0	0.74	0.48
<i>Giardia</i> spp.	0	0	1.0	1	0	0.36	1.0
<i>Entamoeba</i> spp.	0	0	1.0	1	0	0.36	1.0
Total	7	2	0.14	25	5	0.001	0.001

A spring and summer, B autumn and winter

The frequencies of positive samples from the rural areas were found to be significantly more than that of the urban areas.

The results revealed also, that there was a significant difference between (the Spring and Summer) seasons and (Autumn and Winter) seasons of the year in rural areas while it was significant in urban areas

This study revealed that the Baermann technique is better than charcoal culture method in the detection of *Strongyloides* larvae, *Toxocara* spp. eggs and *Ascaris* eggs. This may be explained by significant role of the adequate moisture and aeration in the growth and development of *Strongyloides* larvae and also in the embryonation of both *Ascaris* and *Toxocara* eggs and this is achieved by continuous exposure of the soil samples to water and air in Baermann technique. In contrast, the charcoal culture aeration is dependent upon spaces between charcoal granules and there is an interrupted water supply (Harada and Mori 1995).

Baerman technique is considered as one of the most sensitive tests available for the assessment of the presence of *S. stercoralis* larvae in both soil and fecal samples (van Doorn et al. 2007). However, controversial results achieved for Baermann concentration in comparison to other methods ranged from 48.5 to 100 % (Blatt and Cantos 2003; Steinmann et al. 2007) (Table 2).

Our study revealed that, most geohelminths are acquired in areas designated as infection foci. These are usually the areas near canal banks, playgrounds, around houses and schools. The distribution of geohelminths eggs varied in the examined localities as the canal banks showed the highest prevalence of geohelminths 80 %. Refuse and wastes were disposed in the streams without any precautions; the presence of trees provides cover for defecating humans and developing larvae and eggs of geohelminths therefore, making such environments conducive for the transmission of geohelminths.

These current results are partially in agreement with the results of other studies, according to Mizgajska (2001), the

most contaminated areas in Poland were city backyards where 38–53 % of soil samples were positive especially in the spring. Blaszkowska et al. (2013) reported also that, the helminth eggs were found in 15.7 % of the samples taken from the area around school sport fields, 7.7 % from park playgrounds and 1.4 % from fenced sandpits.

Toxocara eggs constituted the highest prevalence among geohelminths in the collected samples from canal banks. This is supported by the findings of El-Shazly et al. (2009) that the highest intensity of *Toxocara* spp. eggs was 13–19 eggs/10 g (30 %) soil at canal banks at Zohra village, El-Minia. In urban areas; the highest intensity was 1–5 eggs/10 g (10 %) soil at canal banks at El-Minia city.

Hanafi et al. (1987) emphasised the current results that *Toxocara* spp. eggs constituted the highest average intensity of soil pollution indoors 100–200 egg/50 g soil and outside houses 100–900 egg/50 g soil in Dakhliya governorate which is mostly similar to Sharkiya governorate in Sudan, where the muddy soil resembles ours in Sharkiya governorate (Woodruff et al. 1981) correlated the highest prevalence of *Toxocara* eggs near canal banks to clay soil which favored the survival of eggs.

Generally, parasitic infections abound in Sharkiya governorate not only because of our population still live in high unsanitary surroundings with constant faecal pollution of soil by cultural habits of the inhabitants but also as a consequence of the environment for easy parasite growth, spread and transmission (Table 3).

The geographical location of the Sharkiya governorate provinces it by an environment characterized by fertile land, warm climate and varied types of the soil e.g. clay, silt and sandy, Muis Sea as a source of water used for irrigation increases the deposition of loam in the soil thus, increasing the humidity, oxygenation and compactness that influence egg survival in the environment.

The study recorded that the relationship between the soil texture the number of positive samples is indirect. Similar results reported by Mandarino-Pereira et al. (2010) (Table 4).

It has shown that, the soil texture or constituents must provide an open, light type of soil for hook worms, promoting egg hatching and larval development, while, *Ascaris*, *Trichuris* and *Toxocara* demand heavy colloidal soils, as the soil composed mainly of the sand doesn't retain water well and thus is lethal to *Toxocara* eggs (Xavier et al. 2010; Sudhakar et al. 2013).

The difference in soil texture may or may not affect the prevalence of different species of geohelminthes. From this point of view, other physical and chemical factors were highlighted.

In this study, the moisture content was evaluated, it was reported that the moisture content was ideally in the range of 23 and 50 %. It has been demonstrated that the ample supply of water in the study locations had also contributed

Table 2 A comparison between the Baermann method and charcoal culture method used in detection of geohelminths stages in soil samples

Parasite	Baermann technique	Charcoal culture technique	<i>P</i> value
<i>Strongyloides</i> spp.	12	1	0.012
<i>Toxocara</i> spp. eggs	200	90	0.03
<i>Ascaris</i> spp. eggs	30	5	0.014
<i>Taenia</i> spp. eggs	2	1	0.7
<i>Ancylostoma</i> spp. eggs	3	0	0.12
<i>Ancylostoma</i> spp. larvae	2	1	0.8
<i>Trichuris</i> spp. eggs	0	0	1.0
<i>Balantidium</i> spp.	20	6	0.04
<i>Giardia</i> spp.	4	3	0.5
<i>Entamoeba</i> spp.	1	0	0.7

There were significant differences between the two techniques in the detection of *Toxocara*, *Ascaris*, *Strongyloides* spp. While insignificant difference in the detection of *Taenia*, *Ancylostoma*, *Giardia* and *Entamoeba* spp. cysts was recorded

Table 3 The distribution of geohelminths in the examined sites all over the year

Examined localities	No. of samples	Strongyloides Larva		Toxocara egg		Ascaris eggs		Taenia egg		Ancylostoma larvae		Ancylostoma egg		Trichuris egg		Balantidium cyst		Giardia cyst		Entamoeba cyst		Total	X ²	P	
		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%				
Canal banks																									
A	20	3	15	6	30	3	15	1	5	1	5	1	5	0	0	0	0	0	0	1	5	16	80	19.8	0.001
B	20	1	5	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10		
Play ground																									
A	20	2	10	4	20	3	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	45	4.29	0.038
B	20	1	5	1	5	0	0	0	0	0	0	0	0	0	0	1	5	0	0	0	0	3	15		
Around schools and home																									
A	20	2	10	2	10	0	0	0	0	0	0	1	5	0	0	1	5	1	5	0	0	7	35	2.29	0.12
B	20	1	5	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10		

A spring and summer; B autumn and winter

The frequencies of positive samples from different sites were found to be significantly different ($\chi^2 = 34.07$, d.f. = 2 and $P = 0.001$). The highest rate of geohelminths was found in the area near the canal banks especially in the (spring and summer) about 80 %

Table 4 The relationship between the texture of the soil and the geohelminthes positive samples

Examined types of soil	No. of samples	Strongyloides Larva		Toxocara egg		Ascaris eggs		Taenia egg		Ancylostoma egg		Ancylostoma larva		Trichuris egg		Balantidium cyst		Giardia cyst		Entamoeba cyst		Total	X ²	P	
		No.	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%				
Sand																									
A	20	1	5	2	10	1	5	0	0	1	5	1	5	0	0	0	0	0	0	0	0	6	30	4.22	0.039
B	20	0	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5		
Clay																									
A	20	4	20	6	30	2	10	1	5	0	0	0	0	0	0	2	10	1	5	1	5	17	85	14.55	0.001
B	20	2	10	2	10	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	25		
Silt																									
A	20	2	10	3	15	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	30	0.53	0.46
B	20	1	5	1	5	1	5	0	0	1	5	0	0	0	0	0	0	0	0	0	0	4	20		

A spring and summer; B autumn and winter

The results of the analysis of soil texture revealed three types of the soil (clay, silt and sand). It was found to be almost positive for geohelminths. There were insignificant differences between the prevalence of geohelminths in the 3 types of soil ($\chi^2 = 34.07$, d.f. = 2 and $P = 0.001$)

to high occurrence of *S. stercoralis* throughout the period of this research and this had agreed with findings of (Umar and Bassey 2010; Maxwell 2005). Moreover, the soil moisture favored the survival of hookworms. The larvae of hookworm remain quiescent in the moisture films of the soil until contact with suitable host. It is reported that larvae migrate in response to the changing moisture conditions of the soil (hygrotopism). The larvae of hookworms are capable of vertical migration up and down in the contaminated soil depending upon the moisture suction. Udonsi and Anya (1981). Adequate warmth and moisture are key features for each of the soil transmitted helminths. Although, *Ascaris* and *Trichuris* eggs are stronger than hookworms L3 and therefore survive drier climate better, however even for *Ascaris* and *Trichuris*, the rates of infection are low in dried climates, so at low moisture human *Ascaris* ova do not embryonate (Brooker and Michael 2000) (Table 5).

Owen (1930) recorded that *Toxocara* eggs may survive for years in the environment, depending on soil type and climatic conditions. These factors were explained by Beaver (1952) as the moisture retaining soil enhanced the development of *Toxocara* eggs, while sunlight or desiccation is responsible for their disintegration.

In the present work, PH degree was detected and reported that the PH level from 8 to 10 was ideal for development of different stages of geohelminths. This finding explained the high prevalence of geohelminths eggs and larvae in the clay type of the soil and near the irrigation canal banks. As, *Sharkyia* is considered an agricultural

governorate with high deposition of the lime usually in the form of agricultural lime its PH is alkaline. Also, the urea is widely used in agriculture as a source of nitrogen. It contains 46 % nitrogen and easily hydrolyzed in the soil by urease to ammonium and bicarbonate ions which make the soil more alkaline (FIFA 2006). There are various factors that affect the hydrolysis of urea and the rate of ammonia volatilization including temperature (Moyo et al. 1989), presence of other chemicals (Troeh and Thompson 1993) and concentration of urea itself (Burns 1978). In contrast, previous studies have measured and used dissolved ammonia as the inactivating agent for the inactivation of *Ascaris* eggs (Sharad et al. 2012; Nordin et al. 2009). The exact mechanism of action of ammonia for inactivation of the helminthic eggs is still not very clear. It has been suggested that higher temperature increases the permeability of the lipid membrane of the egg- shell allowing the un-ionized ammonia entry inside and disturbing the intra-ovular pH balance causing inactivation (Pecson et al. 2007) (Table 6).

Our study revealed that there is an increase of the prevalence of geohelminths with the increase of the content of the organic matter. The organic matter takes its name from the organic materials that farmers use as an alternative to synthetic fertilizers. It is a mixture of plants and vegetation or fecal matter. It adds nutrients and also fibrous material that help in promoting soil structure (Christensen 2001). The Organic matter can modify the physical and chemical properties of the soil due to its role in promoting the texture of the soil and the presence of vegetation tends

Table 5 The relationship between soil water content (moisture) and positive samples of geohelminths

H ₂ O (%)	Parasite										Total
	Entamoeba cyst	Giardia cyst	Balantidium spp.	Trichuris spp. eggs	Ancylostoma spp. larva	Ancylostoma spp. eggs	Taenia spp. eggs	Ascaris spp. eggs	Toxocara spp. eggs	Strongyloides spp. larva	
10	0	0	0	0	0	0	0	0	1	0	1
20	1	1	2	0	2	2	1	5	10	8	3
50	0	0	0	0	0	0	0	1	4	2	7

The prevalence of geohelminths was positively associated with the increase in the moisture of the soil and the optimum one is 20 % ($P = 0.000$)

Table 6 The relationship between soil PH and positive samples of geohelminths

PH	Parasite										Total
	Entamoeba cyst	Giardia cyst	Balantidium spp.	Trichuris spp. eggs	Ancylostoma spp. larva	Ancylostoma spp. eggs	Taenia spp. eggs	Ascaris spp. eggs	Toxocara spp. eggs	Strongyloides spp. larva s	
7.1	0	0	0	0	0	0	0	0	1	1	2
8.1	1	1	2	0	1	2	1	4	10	7	29
9.9	0	0	0	0	0	0	0	2	4	2	8

The prevalence of geohelminths was positively associated with the increase in the PH of the soil i.e. towards alkalinity ($P = 0.000$)

Table 7 The relationship between soil organic matter content and positive samples of geohelminths

Organic matter	Parasite										
	Entamoeba cyst	Giardia cyst	Balantidium spp.	Trichuris spp. eggs	Ancylostoma spp. larva	Ancylostoma spp. eggs	Taenia spp. eggs	Ascaris spp. eggs	Toxocara spp. eggs	Strongyloides spp. larva	Total
1	0	0	0	0	0	0	0	0	1	0	1
2	1	1	0	0	0	0	0	1	4	2	9
3	0	0	2	0	1	2	1	5	10	8	29

The prevalence of geohelminths was positively associated with the increase in the organic matter content of the soil. ($P = 0.000$)

to prevent evaporation and conserve the soil moisture (Komiya and Yasuraoka 1966). It is reported that the hookworm larvae may migrate in response to the changing moisture conditions of the soil and exhibit negative geotaxis that tend to bring and align it within 15 mm of the top surface of faecally polluted soil and even onto surface debris and low-growing vegetation which are common features of the study sites. This is consistent with Amadi and Uttahé (2010) (Table 7).

In conclusion, Analysis of prevalence data on geohelminths showed a close relationship between the physicochemical characters of the soil and the distribution of geohelminths but the climate has the upper hand upon the characters of the soil. Therefore, control of geohelminths by rendering the soil in the highest prevalent areas unsuitable for development of infective stages or by interfering the contact between the infected soil and the individuals in the governorate. These results also open the way to further studies to highlight the mutual affection between inhabitants of these sites and the prevalence of these geoparasites like the prevalence rate of human infections by the present geoparasites. As well as the relationships between the behaviors of those people in the studied localities and the presence and the distribution of geoparasites also. Some experimental studies should be performed to test the physicochemical characters of the soil in a trial to control geoparasite prevalence and transmission without altering the environmental condition.

Results

On examining the different soil samples by different methods these parasites were detected i.e. geoparasites: *Strongyloides* spp., *Toxocara* spp. eggs, *Ascaris* spp. eggs, *Taenia* spp. eggs, *Ancylostoma* spp. eggs and larvae and *Trichuris* spp. eggs and other parasite stages: *Balantidium* spp., *Giardia* spp. and *Entamoeba* spp. cysts.

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