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Estimation of Geohelminthes prevalence in Soil Samples and risk factors to exposure in Ojo Area of Lagos State, Nigeria

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Abstract:- Soil transmitted helminths (STHs) are intestinal parasites causing neglected tropical diseases of public health concern. It is important to map out soil environments contaminated with STHs and to project which communities people need health interventions. This study investigated the prevalence of STHs in relation to the soil type and risk factors in four communities in Ojo Local Government Area of Lagos State, Nigeria. A total of 100 soil samples with 25 samples from each community were collected. The soil samples were sorted out by texture and categorized into sandy, loamy, humus and clay soils. The parasite stages from soils were identified microscopically after isolation by floatation and sedimentation methods. Sandy soil was the predominant soil type collected (> 40%) in the four communities. Bivariate Pearson's correlation was used to assess the relationship between soil types and STHs. There was a correlation between sandy soil and STHs contamination. Overall, 78% of the soil samples were positive for STHs with sandy soil having 51.2% contamination. Toilet areas had the highest contamination with STHs (25.6%) followed by walkways (24.3%). *Strongyloides stercoralis* was the most prevalent STHs (3.84 %), followed by *Ascaris lumbricoides* (30.7 %), *Necator americanus* (20.5 %) and *Trichuris trichiura* (2.56 %). Mixed infections of *S. stercoralis* and *A. lumbricoides* (7.69%) was recorded. The prevalence of STHs was highest at Alaba- Rago (37.1 %) and lowest at Iba Estate (11.5%). Multinomial logistic regression analysis showed that the factors that influenced the high prevalence of STHs at Alaba-Rago included poor environmental sanitation, lack of toilets, low level of awareness and open defeacation. Health education with provision of public toilets with regular and efficient water supply is advocated. Targeting affected communities for soil decontamination and deworming programmes is also recommended.

Key words: Open defeacation, geohelminthes, soil contamination, intestinal parasites, parasites

I. Introduction

Soil-transmitted helminthes (STHs), also known as geohelminthes are causes of serious global health problems. This group of intestinal parasites thrives in soils in warm humid climates where the soil is humid and sanitation and hygiene are poor (Darlan *et al.*, 2019). Soil transmitted helminthes affect more than two billion people worldwide with Nigeria having the highest burden in sub-Saharan Africa (Otubanjo, 2013). The geographical distribution of STHs is influenced by various factors including environmental conditions like soil, absence of sanitary facilities, types of toilet and human factors including age, sex, socio-economic status, sociocultural beliefs and occupation (Belyhun *et al.*, 2010).

Human-soil contact is a major predisposing factor in transmission of the STHs. Open defeacation usually leads to contamination of soil with eggs and larvae of STHs (Ekundayo *et al.*, 2007). Open defeacation occur due to lack of suitable toilet facilities, which is occasioned by poverty and cultural misconceptions. This activities lead to parasitism which kills about 1.8 million people yearly, many of which are children (Okwa *et al.*, 2018).

Soil transmitted helminthes are among the world's neglected tropical diseases (NTDs) and are the largest contributor to NTDs, which accounts for 85% of the disease burden (Ojurongbe, 2013). Unfortunately, STHs have received less attention by health policy makers, especially in this COVID-19 era even though they inflict tremendous disability and suffering. However, Soil transmitted helminthes can be avoided, controlled or eliminated (WHO, 2012).

The precise global distribution of STHs infection rate and risk of morbidity remains poorly defined (WHO, 2017). This had limited how national governments and international organizations define and target resources to combat the burden of STHs infections (Brooker, 2010). Despite the increased emphasis on the role of good sanitation and hygiene in the control of STHs, majority of the population still do not understand the relationship between unhealthy practices and STHs infections, particularly in rural villages

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and slums (WHO, 2017; Zachary *et al*., 2018). With the worsening economic conditions in Nigeria today, the level of poverty has escalated thereby worsening the problem of poor environmental sanitation (Ukibe *et al*., 2018).

The World Health Organization (WHO) published a comprehensive roadmap to combat NTDs by 2030 and had set the goal of achieving 75% mass drug administration (MDA) coverage in all endemic countries. World Health Organization's initiative was further strengthened by the London declaration with a commitment from pharmaceutical companies and other organizations to support global efforts to control or eliminate 10 specific NTDs including STHs (WHO, 2020).

According to Ohiolei *et al.* (2017), the need to appraise prevalence data overtime is imperative as this would inform on the gains or losses in the status and control of STHs. In the past, 90% of the investigations on STHs have reported prevalence based on feacal samples obtained from participants, in several tropical and sub-tropical countries including Nigeria and only a few were related to soil samples (Nwoke *et al.* 2013; Hassan *et al*. 2017; Hassan and Oyebamiji, 2018).

It is more convenient and less time consuming to use non- human samples by mapping out soil environments contaminated with STHs in order to project, which areas need health interventions. Past studies on STHs were conducted more in rural than urban areas. This present study investigated the prevalence of STHs on contaminated soil and not feacal samples in some selected urban communities in Ojo Area of Lagos State. The aim of this study is to estimate the prevalence of STHs in the soil in relation to the soil type and the associated risk factors in the selected communities. This will help map out soil environments contaminated with STHs and project communities where people need health interventions.

II. Materials and methods

Study area

The study was carried out in four communities in Ojo Area, Lagos State, which is located between Badagry and Amuwo-Odofin Areas in Lagos metropolis Ojo Area is multi-ethnic and inhabitants include the Igbos, Hausa, Aworis and other Yoruba ethnicity. Lagos State University (LASU) is located in this Area. Geographically, Ojo Area is about 37km west of Lagos mainland and located between latitude 4^0 55′N and latitude 4^0 17′N and longitude 12^0 55′E and 13^0 E (Figure 1).

Study communities

The selected study communities within Ojo Area were: Jagun in Petroleum Pipeland Limited (PPL), Iyana Iba, Alaba-Rago and Iba Estate, which are in close proximity to LASU (Figure 2). Jagun-PPL area is a densely populated informal community on the west side of LASU main campus. This community is along the transport route to Okokomaiko along the Lagos-Badagry Expressway. It is mainly a residential area with shops attached to most of the houses. There are several private students' hostels in the community. Most of the adult populations are semi-literates. The environment is filthy and with open drainages that are usually flooded during the rainy season.

Iyana- Iba (way to Iba) community is along the Lagos-Badagry expressway (Figure 2). The inhabitants are semi-literates or illiterates. The area is muddy, water-logged and not motorable during the rainy season. The popular Iyana-Iba local food market is located in this community.

Alaba-Rago (yard of rams), is a part of Alaba international market, which is located along the popular Lagos-Badagry Expressway (Figure 2). It is primarily a market for livestock. It is also a one-stop-shop for metal and wood scrap. Most of the traders are illiterate or semi-literates. The area is characterized by dark filthy water, mud, refuse dumps and animal dung. The roads are not motorable during the rainy season.

Iba low-cost housing Estate is a residential community along Iba Express road leading to Iba Town on the LASU-Isheri road (Figure 2). It is densely populated and houses people from all socio-economic status consisting of civil servants and traders. Most of the adult populations are mainly literates and few semi-literates. Most of the roads are muddy and flooded during the rainy season.

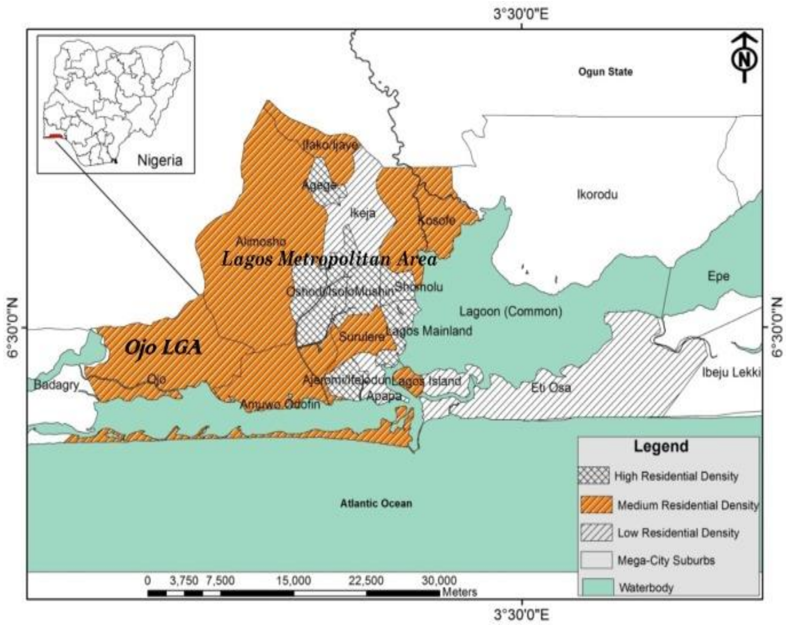

Figure 1. Map of Lagos State showing Ojo area with an insert of map of Nigeria.

Source: Lagos Bureau of Statistics (2022)

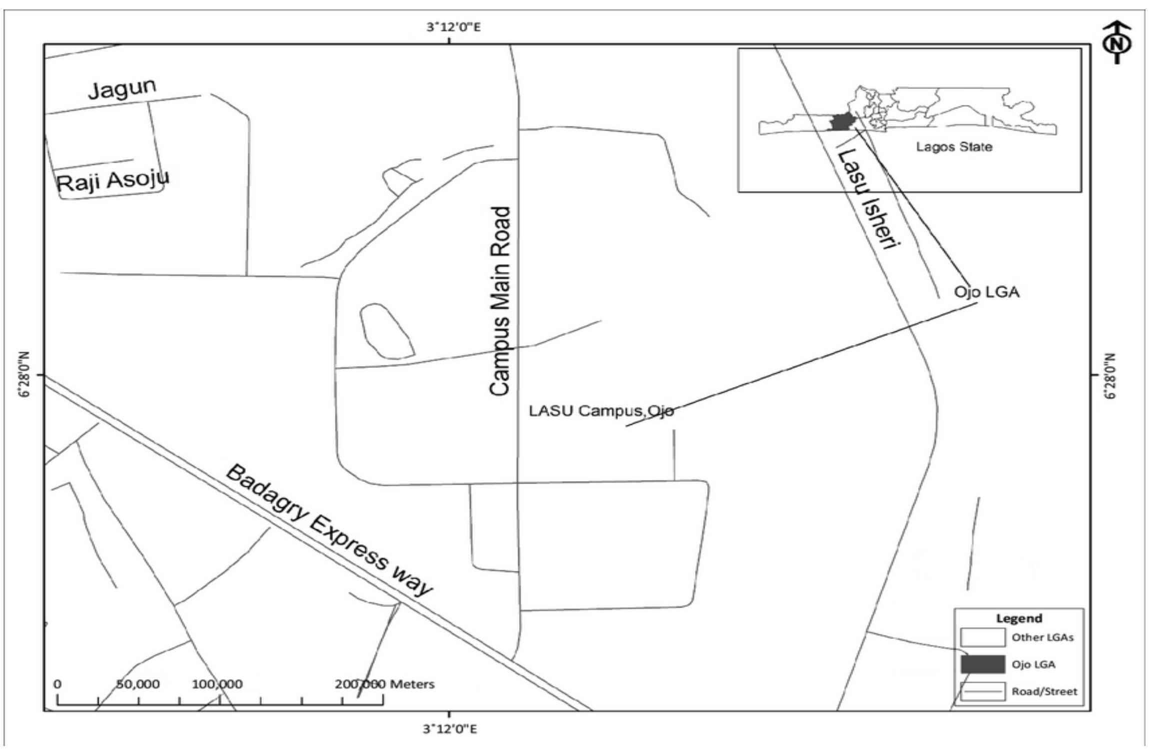

Figure 2. The study area within Ojo area of Lagos State.

Source: Lagos Bureau of Statistics (2022)

Collection of soil samples

A total of 100 soil samples comprising of 25 samples from each of the four communities were systematically collected from five sample points at each site. The five samples were collected respectively from dumpsites, toilet areas, roadsides, main roads and

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walkways in each community. Soil sampling was carried out in the early rainy season (April-June, 2022) and between 6.00am and 11.00am when the infective stages were still present and fresh in the topsoil. One hundred grams (100g) of soil was collected randomly at a depth of 2-3cm, using shovels and stored in sterile, capped and well labelled wide mouthed plastic bottles. The soil samples were taken to the laboratory of the Department of Zoology and Environmental Biology LASU, kept in racks at room temperature and examined immediately.

Determination of soil type

Ten (10) grams of each soil sample was examined and grouped into appropriate textural class according to the method of Olabiyi *et al*. (2009). The texture was determined by the relative content of particles of various sizes such as sand, silt and clay in the soil. The soil samples were then classified into sandy (small particles of weathered rocks), loamy (medium sized particles of sand, silt and clay), clay (with the smallest particles) and humus (black, loose, crumby top soil) according to the method of Robinson (2005). Soil moisture (wet, damp or dry) was determined by the finger pinch soil test of Dumroese (2012). The smell of the soils was determined by orthonasal olfaction.

Parasitological examination of soil samples

Ten (10) grams of each soil sample was collected from each sample using a wooden spatula and this was replicated thrice. Stones and coarse particles were discarded using a sieve mesh (200 um), 5ml of distilled water was added and then mixed thoroughly. The mixed sub-samples were allowed to settle overnight in a beaker prior to examination according to the method of Kazaco (1983). The next day, the supernatant was decanted, leaving the sediments at the bottom of the beakers. Parasite isolation was carried out according to the method of Amoah *et al* (2016). To the sediments in the beakers, 100ml of 0.5% Tween-20 was added, mixed and decanted after10 minutes.

A sterile spatula was used to stir and homogenize the mixture, which was further broken up by shaking and tapping. The sediments were transferred into 50ml centrifuge tubes. The beakers were rinsed with sterile water and the rinsed water was added to the centrifuge tubes to ensure complete transfer of the eggs. The sediments in the tubes were centrifuged at 1500rpm for three minutes. Thereafter, the supernatant was gently poured away and about 150 ml $ZnSO_4$ solution (specific gravity = 1.3) was added to the sediments to allow the eggs to float on the suspension.

A sterile spatula was used to stir and homogenize the mixture, which was then subjected to centrifugation again at 1500rpm for three minutes. The supernatant, which contained the eggs was poured into 2 litre beakers and diluted with 1 litre of distilled water and allowed to settle for about three hours to get the eggs to resettle. The process of centrifugation was repeated by decanting the supernatant and transferring the sediments into 50ml centrifuge tubes, together with rinses of the 2 beakers. The sediments for each sample were transferred into a centrifuge tube and centrifuged at 1500rpm for three minutes. A 15ml acid/alcohol buffer solution (5.16ml of 0.1N H_2SO_4 in 350ml ethanol) and about 5ml ethyl acetate were added to the sediment and shaken, occasionally letting out the gas. The mixture was then centrifuged at 2200rpm for three minutes. Finally, the diphasic supernatant was sucked off, as much as possible, leaving about 1ml of sediment for microscopic analysis.

Identification of soil transmitted helminthes

Ova and larvae of helminthes were identified and counted using a binocular Olympus compound microscope with the guide of an Atlas of Human Parasitology (Ash and Orihel, 2007). Only viable ova were identified with morphological characteristics as specific to different types of STHs. *Necator americanus* larvae was distinguished by a routed head, marked striations at the posterior end, apparent gap between the intestine and prominent oesophagus, and short pointed tail compared to *Ancylostoma duodenale* (Otubanjo, 2013).

Determination of Study Population

A minimum sample size was determined using the sample size determination formula for cross-sectional study according to Harun *et al*. (2019)

n=$Z2pq/d2$.

Where n is the minimum sample size.

Z is the standard normal deviate at 95% confidence interval which is 1.96.

P is the proportion of respondents from a previous similar study

q is the complementary probability 1-p (1-0.81 = 0.19)

d is the precision of the study set at 0.05.

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According to this formula the minimum sample size was calculated as 19.9.

Hence, 20 participants were selected.

Informed consent

Twenty participants that consisted of five adult consenting permanent members of each community were requited into a non-formalized interview. Privacy, confidentiality and anonymity of the participants were ensured.

Conduction of informal interviews

The preferred research method for communities with illiterate and semi-illiterate people are informal interviews (Agboola *et al.* 2003). Observations of the communities were supplemented with non-formalized interviews as a second exploratory approach (Anol, 2012). Yoruba or Pidgin English was the language of communication.

Interview questions and ranking scale

Observations on number of dumpsites were recorded in each community. Questions were asked on the number of households, availability of toilet facilities, practice of open defecation, level of sanitation and level of its awareness and ranked on a scale of 0-None, 1-Very Poor, 2--Poor, 3-Inadequate, 4-Above Average, 5-Adequate, 6-High and 7-Very High.

Statistical analysis

Prevalence of STHs in soil was calculated as percentage of the number of STHs in the soil in each community over the total parasite count. Bivariate Pearson's correlation using Statistical Package for Social Sciences (SPSS version 25) was employed to assess the correlation between soil types and STHs contamination in each community. One-way analysis of variance (ANOVA) test was used to compare the different variables in each community. The data obtained from the interview was analyzed with Microsoft Excel and represented in tables. Multinomial regression analysis using SPSS was used to determine the effects of identified risk factors on the prevalence of STHs. Level of significance was estimated at 5% with 95% confidence interval (C.I). Probability (p value) was determined at $p < 0.05$ as significant and $p > .05$ as not significant.

III. Results

Soil types in the four communities

Out of 100 soil samples, four soil types were encountered during the survey of STHS: (Sandy, loamy, humus and clay). Sandy soil was the predominant soil type (at least 40%) in all the four communities compared to the other soil types (Figure 3). Four soil types were found in Alaba- Rago but the most encountered were sandy and loamy soils (40% each), while the least encountered soil type was clay soil (10%) which was collected only at Alaba-Rago.

Only three types of soil were found in the other three communities. Jagun -PPL and Iyana- Iba had more sandy soil (70%) and (60%), respectively while Iyana- Iba had (30%) humus soil (Figure 3). Majority of the soil samples collected in the communities were damp, (60%) in Jagun- PPL, (60%) in Iyana- Iba, (30%) in Alaba- Rago and (70%) in Iba Estate. The dampest soil was collected at Iba Estate (70%), while the wettest and smelliest soil was collected at Alaba -Rago (40%) and the driest but less smelly was collected at Jagun-PPL (40%).

Soil samples sites in association with STHs contamination

Out of the 100 soil samples collected, 78 (78 %) had at least one species of STHs. Overall, soils collected from toilet areas had the highest contamination 20 (25.6%), followed by walkways 19 (24.3%), Roadsides and dumpsites 15 (19.2%) each and Mainroads 9 (11.5%) was the least. The percentage of soil contamination from the four communities are as follows: 24 (96%) from Alaba Rago, 21 (84%) from Ijagun-PPl, 19 (76%) from Iyana iba and 14 (56%) from Iba Estate (Table 1).

Soil types in association with STHs contamination

Sandy soil was the predominant soil collected (40-70%) and with the highest STHs contamination in the four communities (Figure 3). Bivariate Pearson's correlation showed a positive relationship between sandy soil and the highest STHs contamination with STHs compared to other soil types. Overall contamination of the soil types were as follows: sandy 40 (51.2%), loamy 29 (37.1%), humus 8 (10.2%) and Clay 1 (1.28%) (Table 2)

Prevalence of ova and larvae in soil samples from the four communities

The prevalence of STHs ova and larvae in the soil was highest at Alaba- Rago with 29 (37.1 %) prevalence. Jagun-PPL had a prevalence of 24 (30.7%) while Iyana-iba had 16 (20.5%). The least prevalence was at Iba Estate with a prevalence of 9 (11.5 %).

The species of STHs recovered and prevalences were: *S. stercoralis* larvae 30 (38.4%), *A. lumbricoides* ova 24 (30.7%), *N. americanus* larvae 16 (20.5%) and *T. trichiura* ova 2 (2.56%). Mixed infections of *Strongyloides stercoralis* and *Ascaris lumbricoides* 6 (7.69%) was recorded in Jagun-PPL, Alaba- Rago and Iba Estate. Significant differences existed in the prevalences of STHs across the five communities ($p<0.05$) (Table 3).

Risk factors identified in the four communities

The informal interviews showed that Iba Estate was the most populated community (> 1000) but there were no dump site observed. It was disclosed that all households had water closet (WC) toilets. The level of sanitation and awareness of the participants were above average. However, Alaba- Rago had an estimated population of (>700) and six dumpsites were observed. But, three of the six dumpsites were feacal dumpsites with polythene bags containing feacal materials.

It was gathered that the WCs were not functional and the pit latrines were bad and inadequate.

Level of awareness and sanitation was generally very poor. Jagun-PPL and Iyana-Iba communities had an estimated population of < 300 and < 400, respectively. Both communities had fewer dumpsites (2-3) and high rates of open defecation. The participants disclosed that there were inadequate pit latrines and WCs. Level of awareness and sanitation was poor. Multiple logistic regression analysis showed that the factors that influenced the high prevalence of STHs included poor environmental sanitation, lack of toilets, low level of awareness and open defecation and the risk of exposure to STHs was highest at Alaba-Rago and least at Iba Estate (Table 4).

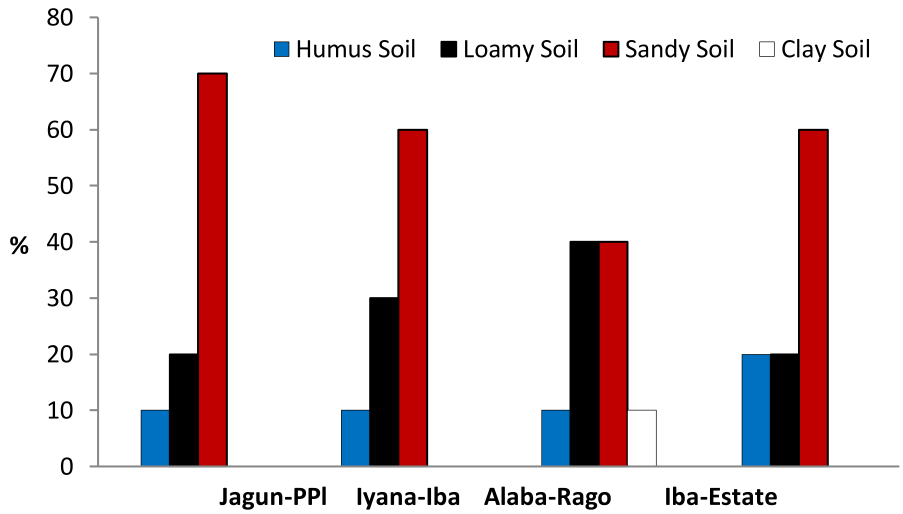

Figure 3: Bar chart showing the soil types (%) collected in the four communities.

Table 1: Soil samples sites in association with STHs contamination

Sampling sites	**Jagun-PPl** No (%)	**Iyana Iba** No (%)	**Alaba-Rago** No (%)	**Iba-Estate** No (%)	**Total** No (%)	P Value 0.214
Dumpsites	5 (23.8)	5 (26.3)	5 (20.8)	0 (0)	15 (19.2)	DF 4
Toilet areas	5(23.8)	5(26.3)	5(20.8)	5 (35.7)	20 (25.6)	P>0.05
Roadsides	5(23.8)	5(26.3)	5(20.8)	0 (0)	15 (19.2)	
Walkways	5(23.8)	4 (21)	5(20.8)	5 (35.7)	19 (24.3)	
Mainroads	1 (4)	0(0)	4 (16.6)	4 (28.5)	09 (11.5)	
Soil infected	21/25	19/25	24/25	14/25	78 /100	
% Soil infected	84 %	76%	96%	56%	(78%)	

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Table 2: Soil types in association with STHs contamination

Soil types	Jagun-PPl N (%)	Iyana Iba N (%)	Alaba-Rago N (%)	Iba Estate N (%)	Total N (%)
Sandy	14 (66.6)	9 (47.3)	10 (41.6)	7 (50)	40 (51.2)
Loamy	5 (23.8)	8 (42.1)	10 (41.6)	6(42.8)	29(37.1)
Humus	2 (9.5)	2 (10.5)	3 (12.5)	1 (7.14)	8 (10.2)
Clay	0 (0)	0 (0)	1(4.16)	0 (0)	1 (1.28)
Total	21/25	19/25	24/25	14/25	78/100
%Soil infected	84 %	76%	96%	56%	(78%)
	DF -3	P-value -0.455	P >0.05		

Table 3: Prevalence of Ova and Larvae in the Soil in the Four Communities

Community N = 25	A.l ova N (%)	N.a N (%)	T.t ova N (%)	S.s larvae N (%)	M.I N (%)	Total N (%)
Jagun-PPL	4(16.6)	2(12.5)	2(100)	12(40)	4(66.6)	24(30.7)
Iyana iba	6(25)	2(12.5)	0(0)	8(26.6)	0(0)	16(20.5)
Alaba Rago	10(41.6)	10(62.5)	0(0)	8(26.6)	1(16.6)	29(37.1)
Iba-Estate	4(16.6)	2(12.5)	0(0)	2(6.66)	1(16.6)	9(11.5)
Total	24 (30.7)	16(20.5)	2(2.56)	30(38.4)	6(7.69)	78%

Df=4 p<0.05

Key: *A.l- Ascaris lumbricoides*, *N.a- Necator americanus*, *T.t- Trichuris trichiura*, *S.s- Strongyloides stercoralis*, M.I- Mixed Infections

Table 4. Association between risk factors and STHs prevalence in the four communities

Variables	**Jagun-PPL**	**Iyana-Iba**	**Alaba-Rago**	**Iba Estate**
Prevalence of STHs	30.7%	20.5 %	37.1%	11.5%
Number of Households	>300	> 400	> 700	>1000
Number of Dump sites	2	3	6	0
Open Defeacation	6	6	7	0
Toilet Facilities	3	2	1	5
Level of Sanitation	2	2	1	4
Level of Awareness	2	2	1	5
P-values	0.55	0.55	0.54	0.79
Df=3	p<0.05			

Key: 0--None, 1-Very Poor, 2--Poor, 3--Inadequate, 4-Above Average, 5--Adequate, 6-High, 7-Very High

IV. Discussion

The presence of STHs eggs and larvae in the soil is of great epidemiological significance and is a serious public health concern. Most STHs infections are transmitted through feacal-oral routes but Uga *et al* (1997) reported that soil is the most direct indicator of risk. Soil is the natural organic material found on the earth's crust which is composed of minerals, nutrients, inorganic particles and biota (living and remains) so the role in maintaining parasite transmission cannot be overstated (Whiting *et al.* 2007). The high soil contamination of 78% obtained in this study, suggest that the environmental conditions in these communities allowed for further development of the voided ova making them retain viability and available for transmission year round. This was evidence by the fact that soil collected from the toilet areas were most contaminated at 25.6% out of 78% of contaminated soil samples collected.

The STHs distribution correlated with the unique characteristics of the soil. Although, sandy soil was the predominant soil type collected, there was a correlation between STHs and sandy soil. It had been reported that hookworms thrive better in damp dirt, sandy or loamy soil or loose humus soil but do not survive in clay or mucky soil (Okwa, 2016; Hassan and Oyebamiji, 2018). According to Nwoke *et al.* (2013), sandy soil have poor water holding capacities so are fast draining which allows for good-aeration and non-adhesion providing optimal conditions for parasites development and could explain the high parasite intensities in such soils. On the other hand, clay soil type had the least STHs compared to the other soil types in this study and this same observation was reported by Hassan and Oyebamiji (2018). The low parasite counts in clay which was only encountered once during the study at Alaba-Rago could be as a result of the high water holding capacity, low water permeability, density, heaviness and the small interstitial pores with no air spaces associated with clay (Hassan *et al*. 2017). This is similar to the work of Olabiyi *et al* (2009), who sampled different soils in southwestern Nigeria and reported that plant parasitic nematodes in each soil varied as a result of textural classes. According to Olabiyi *et al* (2009), nematodes occupy the sandier parts of soil and sandy soil had more nematodes specie than other soil types. Olufotebi *et al.* (2019) also reported high prevalence of *S. stercoralis* in a study of STHs in the soil in Ibadan, Oyo State.

In this present study, four types of STHs were found with *S. stercoralis* larvae being most prevalent (38.4%) in sandy soil. This could be because this helminth can live for up to 3 weeks in the soil under optimal condition ns with temperature of 20-28ºC and high moisture (Conway *et al*. 1995). *A. lumbricoides* ova were found more in the sandy soil type compared to other soil types. *A. lumbricoides* eggs are resistant to harsh environmental conditions which may account for the ubiquitous nature of eggs distribution and hence high abundance in soils in the sampled areas. The high contamination rate may also be due to the fact that most of the soil samples were damp and moist and this correlated with the findings from other studies reported by Ogbolu *et al.* (2011) and Nwoke *et al*. (2013). The condition of the soils was worst at Alaba –Rago having the dampest, smelliest and moister soil samples. Ohiolei *et al.* (2017) reported that helminthes eggs thrive better in soils in humid environments more than in dry and arid conditions and this is in line with the results of this work.

The species of STHs found in this study are in line with the reports of Hassan *et al* (2017) and Ogbolu *et al* (2011) where all STHs types were detected but differs from the report of Oyebamiji *et al* (2018) in which *T. trichiura* ova was undetected. This also implies that the higher the moisture content, the higher the intensities of parasites because moisture content aid the survivability of parasites.

The low level of soil contamination in Iba Estate despite more households' vicinities could be due to better level of awareness of sanitation and no dump sites when compared to the other areas. This observation is significant since open defecation is not a common practice in this community. On the contrary, Alaba- Rago with the worst soil sanitation had the highest level of STHs prevalence (37.1 %) and 96% of soil collected had STHs. This could be because this community is an urban slum, particularly with 6 dumpsites, and poor and inadequate toilet facilities. It was observed that some of the inhabitants defeacate in polythene bags and dispose their waste around three dump sites resulting in soil pollution.

This calls for concern because of the World Health Organization's 2025 zero targets for open defeacation (WHO, 2020). It is also important to note that apart from the practice of open defecation due to lack of modern toilets facilities, low access to standard water, inadequate public enlightenment on the danger of open defecation is lacking among the inhabitants. It is a known fact that STHs in the soil are more prevalent where open defecation is practiced indiscriminately and identified risk factors that have been identified were lack of toilets, overcrowding, poverty and ignorance (Ibidapo and Okwa , 2008; Okwa *et al.* 2018). No doubt, high rainfall combined with low level of awareness, hygiene, and the known hardy nature of STHs eggs and larvae provides a fertile environment for STHs transmission.

V. Recommendations

There is a need for proper education on STHs transmission in communities such as the Alaba- Rago community. Health education on the harmful effects of indiscriminate open defecation is crucial, to break away from a high risk of exposure. Provision of mobile or public toilets with regular water supply and efficient flush systems and targeting endemic communities for soil decontamination and deworming programs are recommended.

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