



Annual Research & Review in Biology

14(3): 1-10, 2017; Article no.ARRB.31546
ISSN: 2347-565X, NLM ID: 101632869

Assessment of Physico-chemical Parameters of Soils in Following Farmlands and Pit Toilet Environments as it Affects the Abundance of Geohelminthes in Emohua Local Government Area, Rivers State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Authors OO and GDBAW designed the study and wrote the first draft. Authors IH and OO managed the analyses and literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARRB/2017/31546

Editor(s):

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Complete Peer review History: <http://www.sciencedomain.org/review-history/19915>

Original Research Article

Received 12th January 2017
Accepted 13th March 2017
Published 7th July 2017

ABSTRACT

Background: This study was conducted to determine the effects of physico-chemical parameters of soils in environments used for open defecation on the abundance of geohelminths in Emohua, Rivers State, South South, Nigeria.

Methods: A total of 720 soil samples were collected randomly from soils found in following farmlands used for open defaecation and around pit toilet environments in Mgbuitanwo, Isiodu, and Rumuche Communities in Emohua local Government Area of Rivers State. Two hundred and forty samples were collected randomly from each of the communities between the months of January-June 2013 and 2014 respectively. The samples were analysed for temperature, pH, and organic content and Centrifugal flotation method was used to examine the samples for geohelminths.

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Results: Evaluation after two variations gave an average of 198(55%) of the soil samples as positive for geohelminths as follows; 16(4.4%), 131(36.3%) and 51(14.1%) for clayey, loamy and sandy soils respectively. This was statistically significant ($p < 0.05$). Results also showed soil temperature mean $27.2^{\circ}\text{C} \pm 5.2$ S.D, soil pH mean 6.3 ± 2.5 S.D and soil organic matter mean $12.7\% \pm 3.6$ S.D, clay soil mean 16 ± 4 S.D, loam soil mean 115.5 ± 10.7 S.D and sandy soil mean 47.5 ± 6.9 . The geohelminths recovered from the samples were 293 as follows; Clayey: 25(8.5%), Loamy: 189(64.5%) and Sandy: 76(26%). *Ascaris lumbricoides* 92(31.4%), *Trichuris* spp. 55(19.5%), *Ancylostoma duodenale* 38(12.9%), *Strongyloidies* spp. 12(4%), *Entrobisus* spp. 10(3.4%), *Trichostrongylus* spp. 5(1.6%), *Schistosoma mansoni* 2(0.6%), *Meloidogyne* spp. 48(16.4%), *Radopholus* spp. 1(0.3%), *Aphelencooidies* spp. 1(0.3%), *Bayliascaris* spp. 5(1.7%), *Toxocara* spp. 21(7.2%) and *Ancylostomacanis* 2(0.6%).

Conclusion: Due to the presence of human, plant and animal infecting geohelminths in the area, the Government should reintroduce sanitary inspection of our environments to check the indiscriminate and unhygienic disposal of human waste.

Keywords: Emohua; environments; geohelminths; soils.

1. INTRODUCTION

Geohelminthes are soil-transmitted parasitic nematodes with lifecycle that involves no intermediate host or vector and are among the most prevalent of chronic human, animals and plants infections worldwide [1]. They are spread by faecal contamination of soil, foods and water, wind and agricultural machinery. You find them in almost all habitats, but are most times overlooked because majority are microscopic in nature [2]. Soil is an excellent habitat for nematodes; a handful of soil may contain several of them [3]. Geohelminthes premature stages (eggs) require a period of development in the soil before they become infective [4]. In 2010 it was estimated that about 1.45 billion people in the world were infected with Soil-Transmitted Helminthes (STHs) and 5.19 million showed associated morbidity [5,6]. Out of 1.45 billion infections due to Soil Transmitted Helminths, 438.9 million were infected with hookworm (*Ancylostoma duodenale* and *Necator americanus*), 819 million with *Ascaris lumbricoides* and 464.6 million with *Trichuris trichiura* and 4.5 billion people at risk of infection with one of the three common soil-transmitted helminths above [6,7]. Majority of the people infected with soil transmitted helminthes are school-aged children from rural communities of sub-Saharan Africa, a region characterized with favourable environmental and human factors that enhance parasite transmission [8,9]. Damage caused by plant nematodes has been estimated at about \$US80 billion per year [10]. However, this is likely to be a significant underestimate of the true figure, because many farmers, particularly in developing nations, are not aware of the existence of plant-parasitic

nematodes, as a result of their usual small nature and most times losses from their nonspecific effects are misconstrued to be loss from other pathogenic organisms or certain environmental factors [11,12]. All crops grown in Nigeria are prone to nematode attack, causing farmers' significant crop loss annually [13]. The infection is promoted by poor hygienic habits such as indiscriminate disposal of human and animal faeces.

In Nigeria, a large amount of human and animal waste is discharged into the soil daily leading to the seeding of the soil with pathogenic organisms including geohelminthes eggs and larvae [14]. This permits contact with faeces and its accompanying microbial load including geohelminthes eggs in the soil. Other risk factors include lack of safe drinking water source, poverty, geophagia, and having pools of water or sewage around the house [15,16]. Soil factors influencing the helminth communities include nutritional environment, carbon conservation and physical changes to the soil structure caused by agricultural operations [17]. Experimental studies suggest that the maximum temperature for the development of *A. lumbricoides* and *Trichuris trichiura* is between 5°C – 38°C [18,1], while the development of hookworm larvae ceases at 40°C [19,20,1]. It is suggested that *A. lumbricoides* eggs are more resistant to extreme temperature than *Trichuris* eggs [21]. Furthermore, soil moisture and relative atmospheric humidity are also known to influence the development and survival of eggs and larvae. Higher humidity is associated with faster development of ova and at low humidity ($<50\%$), the ova of *A. lumbricoides* and *Trichuris trichiura* do not embryonate [22]. Field studies show that the abundance of

hookworm larvae is related to the atmospheric humidity [23].

This study was conducted to determine the effects of physico-chemical parameters of soils in environments used for open defecation on the abundance of geohelminths. The information will not only help in better understanding of geohelminths distributions, but also to serve as geographic decision-making tools for identifying areas at risk as well as for the design, implementation and monitoring of soil environment control programmes by health organizations.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Emohua Local Government Area of Rivers State Nigeria. Its headquarter is in the town of Emohua. It is located at 4°53'0" North 6°52'0" East of the Greenwich. It has an area of 831 km² (321 sq mi) and a population of 201,901 at the 2006 census [24]. The area lies within the tropical rain forest vegetation zone and inhabitants are mostly traders and farmers. Emohua features a tropical monsoon climate with lengthy and heavy rainy seasons and very short dry seasons with an average temperature range of 26°C. Three Communities; Isiodu, Mgbuitanwo, and Rumuche, were selected for this research. These communities were selected based on their defecation patterns; where following farmland and Pit toilets are used as toilets. Samples were collected monthly from each of the study sites between the months of January- June 2013 and 2014.

2.2 Ethical Clearance for the Study

Permission to conduct the study was got from the community heads. During routine visits to the community heads, the relevance of the study was explained. The community heads further assembled their subjects and explained same to them.

2.3 Collection of Soil Samples

Sample collections were done in the morning from about 6am – 12 noon when the larvae and eggs of geohelminthes are still active. Sterile soil auger was used to collect 15cm topsoil from randomly selected points. An average of 60 samples was collected each month. The soil

samples collected were kept in sterile black polythene bag and taken back to the Animal and Environmental Biology laboratory for analyses.

2.4 Examination of Soil Samples

2.4.1 Temperature

The temperature of the soils was tested with thermometer during sample collection using ClimeMET CM3011 Soil Thermometer [1].

2.4.2 Measurement of soil pH

The reference electrode of the corning pH meter was inserted into the top 1cm of the moist soil surface. The knob of the pH meter was switched on for about 30 seconds and the value of pH meter recorded. Later, the reference electrode was rinsed with distilled water that was taken to the site from the laboratory between each soil sample reading. After the reading, the knob of the pH meter was switched off [1].

2.4.3 Soil texture

The field method of using hand was employed to determine the soil texture according to [25]. The sand content was determined by rubbing a small amount of soil in the palm of the hands to determine if sand is under or over 50%, if the sand content is less than 50%, water is to be added to create a soil that is wet enough to roll. The soil was squeezed between the thumb and forefinger to make the longest ribbon possible, a loam soil will form only a short ribbon, while a clay soil will form a much longer ribbon.

2.4.4 Determination of organic matter in the soil

The organic matter (carbon) was determined by ashing a 5 gram scoop of the soil sample at 360°C for 2hours in a muffle furnace. The loss by weight of the sample during this ignition is calculated as the organic matter. Results are reported as percent organic matter by weight in the soil [26].

2.5 Examination of Soil Samples for Eggs and Larvae of Geohelminthes

2.5.1 Centrifugal flotation method

The soil samples were sieved using a fine sieve (Pore size 250 µm) so as to remove larger particles but also allow passage of small size

particles including helminth eggs. From the sieved portion, 2 g of soil was collected and placed into a 10 ml test tube containing 3 ml of 30% sodium hypochlorite solution, the test tube was shaken intermittently then 5 ml of concentrated saccharine solution (1000 g of white sugar in 900 ml of distilled water) was added to the test tube and then put in the centrifuge (model HW236) and was set to centrifuge at 1500 rpm for 15 minutes. After the 15 minutes timer is out, the test tubes were removed from the centrifuge and more saccharine solution is added to raise the meniscus and float the eggs. Cover slips were put on the top of the test tubes and wet them by the surface of the floating solution after allowing standing for 15 minutes. The cover slips were carefully removed from the top of the test tubes and gently placed on microscope slides, the slides were examined microscopically for presence of helminths larvae or eggs. The cover glasses were carefully removed from the top of the tubes and placed on microscope slides, the slides were examined microscopically at 40x magnification for the presence of helminthes eggs/ova [27]. The eggs and larvae of human helminths were identified with reference to Atlas of Parasitology [28]. Plant nematodes were identified using atlas on identification of plant-parasitic nematodes [29].

2.6 Data Analysis

Results obtained from the samples were entered into Ms. Excel 2007 and analyzed using standard deviation and one way analysis of variance (ANOVA) statistical tool was used to assess significant differences in prevalence of geohelminthes. Descriptive statistics were calculated and presented in form of tables [30].

3. RESULTS

An average total of 360 soil samples of different textural classes were examined during the study period for geohelminths. One hundred and ninety-eight 198 (55%) were positive as follows; 16 (4.4%), 131, (36.6%) and 51 (14.1%) for clay, loamy and sandy soils respectively. Thirty-seven (61.6%) of the samples were positive in Mgbuitanwo 1 as follows; 4 (6.6%), 24 (40%) and 9 (15%), 37 (61.6%) of the samples were positive in Mgbuitanwo 2 as follows; 1 (1.6%), 27 (45%) and 9 (15%), 34 (56.6%) of the samples were positive in Isiodu 1 as follows; 1 (1.6%), 21 (35%) and 12 (20%), 35 (58.3%) of the samples were positive in Isiodu 2 as follows; 3 (5%), 24 (40%)

and 8 (13.3%), 29 (48.3%) of the samples were positive in Rumuche 1 as follows; 6 (10%), 14 (23.3%) and 9 (15%), 26 (43.3%) of the samples were positive in Rumuche 2 as follows; 1 (1.6%), 21 (35%) and 4 (6.6%) for clay, loamy and sandy soils respectively (Table 1).

An average total of 360 soil samples made up of clay, loam and sand collected during the study period in Emohua had physico-chemical properties as follows; 27.2°C, 6.3 and 12.7 for temperature, pH and %organic matter with a total of 293 geohelminths were recovered from the samples as follows; *Ascaris lumbricoides* 92 (31.4%), *Trichiuris* spp. 55(19.5%), *Ancylostoma duodenale* 38 (13%), *Strongyloides* spp. 12 (4%), *Enterobius* spp. 10 (3.4%), *Trichostrongylus* spp. 5 (1.7%), *Schistosoma mansoni* 2 (0.7%), *Meloidogyne* spp. 48 (16.4%), *Radopholus* spp. 1 (0.3%), *Aphelencoides* spp. 1 (0.3%), *Bayliascaris* spp. 5 (1.7%), *Toxocara* spp. 21 (7.1%) and *Ancylostoma canis* 3 (1.0%). Physico-chemical parameters of clay soils were 26.5°C, 6.5, and 10.7% for temperature, pH and %organic matter with a total of 25 (8.4%) geohelminths recovered as follows; *Ascaris lumbricoides* 9 (36%), *Trichiuris* spp. 8(32), *Ancylostoma duodenale* 2 (8%), *Meloidogyne* spp. 4(16%), *Bayliascaris* spp 1(4%) and *Toxocara* spp 1(4%). Physico-chemical parameters of loam soils were 27.5°C, 6.2, and 14.9% for temperature, pH and %organic matter with a total geohelminths of 189(64.5%) recovered as follows; *Ascaris lumbricoides* 58 (30.6%), *Trichiuris* spp. 32(16.9%), *Ancylostoma duodenale* 26 (13.7%), *Strongyloides*spp. 10 (5.2%), *Enterobius* spp 9(4.7%), *Trichostrongylus* spp. 4(2.1%), *Schistosoma mansoni* 2(1%), *Meloidogyne* spp. 28(14.8%), *Radopholus* spp. 1(0.5%), *Aphelencoides* spp. 1(0.5%), *Bayliascaris* spp. 4(2.1%), *Toxocara* spp.13 (6.8%) and *Ancylostoma canis* 1 (0.5%), while Physico-chemical parameters of sandy soils were 27.7°C, 6.3, and 12.6% for temperature, pH and %organic matter with a total of 79(27%) as follows; *Ascaris lumbricoides* 25(31.6%), *Trichiuris* spp. 15(18.9%), *Ancylostoma duodenale* 10(12.6%), *Strongyloides* spp. 2 (2.5%), *Enterobius* spp. 1(1.25%), *Trichostrongylus* spp. 1(1.25%), *Meloidogyne* spp. 16 (20.2%), *Toxocara* spp. 7(8.8%) and *Ancylostoma canis* 2 (2.5%). See Table 2.

Soil temperature mean 27.2°C ± 5.2 S.D, soil pH mean 6.3 ± 2.5 S.D and soil organic matter mean 12.7% ± 3.6 S.D, clay soil mean 16 ± 3.5 S.D, loam soil mean 115.5 ± 10.7 S.D and sandy soil

mean 47.5 ± 6.9 . Loamy soil had highest number of 233 samples, sandy soil had 95 samples, and clay had 32 samples. See Table 3.

Out of the two hundred and ninety-three geohelminthes recovered during the study period, 155 (52.9%) was recovered between the

months of January- March with physico-chemical parameters as follows; 27.7°C, 5.9 and 14% for temperature, pH and %organic matter while 138 (47.1%) was recovered between the months of April-June with physico-chemical parameters as follows; 26.3°C, 6.7 and 12.2% for temperature, pH and %organic matter (Fig. 1).

Table 1. Prevalence of geohelminthes in the soil types of the study area

Sampling sites	Average no. of soil sampled	Soil types positive for geohelminthes (%)			Total no. of soils positive for geohelminthes (%)
		Clay	Loamy	Sandy	
Mgbuitanwo 1	60	4 (6.6)	24 (40.0)	9 (15.0)	37 (61.6)
Mgbuitanwo 2	60	1 (1.6)	27 (45.0)	9 (15.0)	37 (61.6)
Isiodu 1	60	1 (1.6)	21 (35.0)	12 (20.0)	34 (56.6)
Isiodu 2	60	3 (5.0)	24 (40.0)	8 (13.3)	35 (58.3)
Rumucho 1	60	6 (10)	14 (23.3)	9 (15.0)	29 (48.3)
Rumucho 2	60	1 (1.6)	21 (35.0)	4 (6.6)	26 (43.3)
Total	360	16 (4.4)	131 (36.3)	51 (14.1)	198 (55.0)

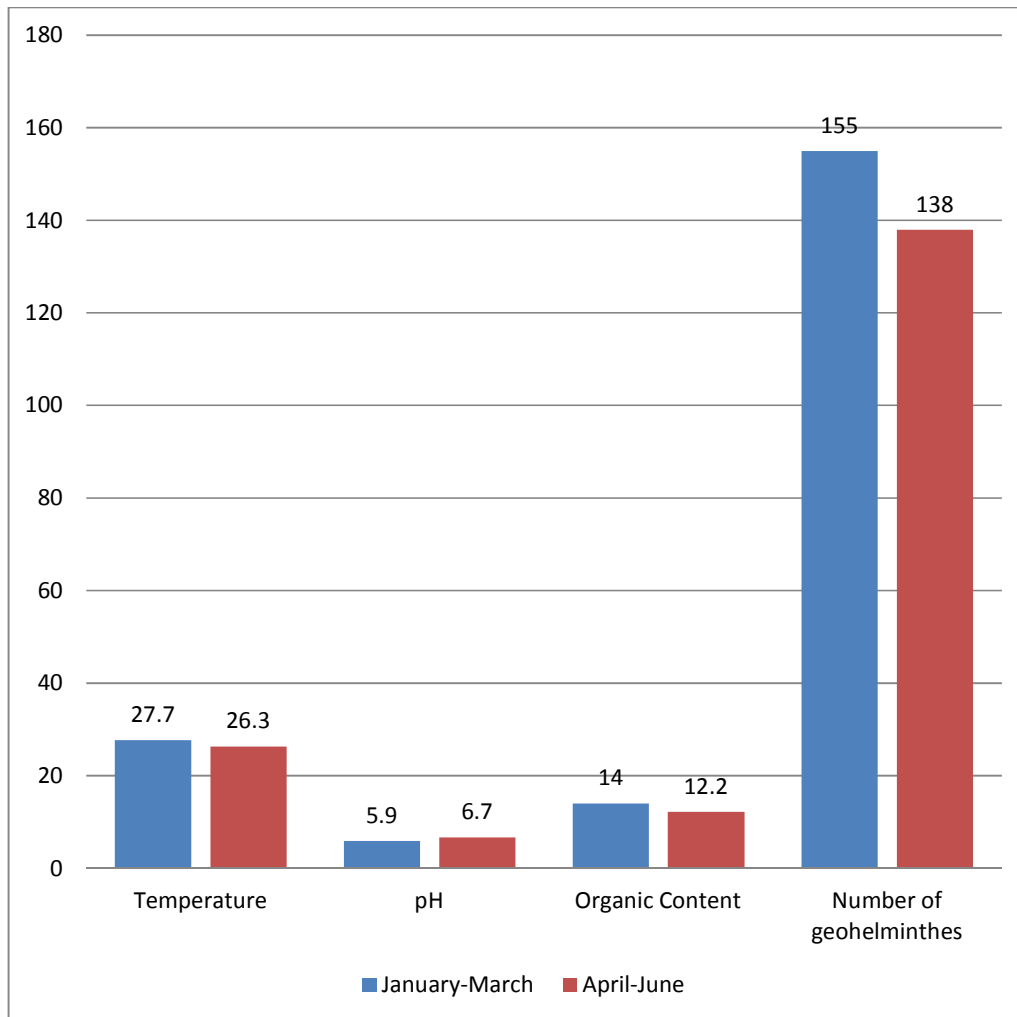


Fig. 1. Temporal variations of Geohelminthes populations in the study area

Table 2. Prevalence of geohelminths as affected by soil Physico-chemical parameters the in Emohua during the study

Soil types	Temperature (°C)	pH	(%) organic matter	<i>Ascaris lumbricoides</i>	<i>Trichuris</i> spp.	<i>Ancylostoma duodenale</i>	<i>Strongyloidies</i> spp.	<i>Enterobius</i> spp.	<i>Trichostrongylus</i> spp.	<i>Schistosoma mansoni</i>	<i>Meloidogyne</i> spp.	<i>Radopholus</i> spp.	<i>Aphelencoidies</i> spp.	<i>Bayliascaris</i> spp.	<i>Toxocara</i> spp.	<i>Ancylostoma canis</i>	% (Total)
Clay	26.5	6.5	10.7	9(36)	8 (32)	2 (8)	0	0	0	0	4 (16)	0	0	1 (4)	1 (4)	0	25 (8.5)
Loam	27.5	6.2	14.9	58 (30.6)	32 (16.9)	26 (13.8)	10 (5.2)	9 (4.7)	4 (2.1)	2 (1)	28 (14.8)	1 (.5)	1 (.5)	4 (2.1)	13 (7.0)	1 (.5)	189 (64.5)
Sand	27.7	6.2	12.6	25 (33)	15 (19.7)	10 (13.1)	2 (2.6)	1 (1.3)	1 (1.3)	0	16 (21)	0	0	0	7 (9.2)	1 (1.3)	76 (26)
(%) Total	27.2	6.3	12.7	92 (31.4)	55 (19.5)	38 (12.9)	12 (4)	10 (3.4)	5 (1.6)	2 (.6)	48 (16.4)	1 (.3)	1 (.3)	5 (1.7)	21 (7.2)	2(.6)	293

Table 3. Soil Physico-chemical parameters the in Emohua during the study

Parameters	N	Mean	S.D	S.E
Temperature (°C)	6	27.2	5.2	2.1
pH	6	6.3	2.5	1.0
(%) Organic matter	6	12.7	3.6	1.4
Clay	32	16	4	0.7
Loam	233	115.5	10.7	0.7
Sand	95	47.5	6.9	0.6

4. DISCUSSION

The results from the study indicated a prevalence of (55%) of geohelminths in the soil samples in the study area with Loamy soil having the highest prevalence of 36.3%. The prevalence in the samples was statistically significant as ($p < .05$). Equally, a temperature of 27.2°C, pH of 6.3 and 12.7% organic matter was recorded and 293 geohelminths recovered from the soil samples of the study area. The temperature of the soils in the area were slightly above room temperature which is suitable for development thriving of infective stages of geohelminths, The temperature ranges agree with [1,31,32,33] who in their various findings agreed that the optimum temperature for the embryonation of soil transmitted helminthes eggs ranges from $16 \pm 1^\circ\text{C}$ and $34 \pm 1^\circ\text{C}$ and as the temperature increases within this range, the development of the egg is hastened. This might be due to the effect of heat to chemical reactions occurring inside the eggs for their development. Enzymes might be activated easily with higher temperature and molecules come in contact more often when excited due to the energy from heat. This is also evident in *Ascaris* eggs which were observed to halt development in freezing temperatures, which may be mainly due to the inhibition of the chemical reactions needed for the egg development [31,33]. The pH was slightly acidic tending towards the neutral point which is equally suitable for the development of the organisms. The pH ranges as observed is in line with studies which mentioned that helminth eggs are said to tolerate a large range of pH. However, *Ascaris suum* eggs were said to have an arrested development when placed in an acidic environment. Hookworms, on the other hand, tolerate pH range of 4.6–9.4 and will still be able to hatch and infect [34].

The organic carbon was equally high ensuring that there are enough nutrients for the survival of the different geohelminths soil dwelling stages. Though the organic matter in the soil types were

almost at the same level, loamy soils had 14.9% organic content which is the highest and more of the geohelminthes recovered with the increase of the content of the organic matter (Table 2). Loamy soils equally has the ability to retain, nutrients, humus and moisture while still allowing excess water to drain away thereby giving the geohelminthes and other microorganisms access to oxygen for their survival. This is in line with work of Samia et al., [35] which revealed that there is a rise in the prevalence of geohelminths with the rise in the content of the organic matter.

Also the continuous seeding of the soil with the infective stages of these parasites through defaecation could also be responsible for this high prevalence of geohelminths. The significant presence of geohelminths infestation in this study conforms to the findings of [25,32,33,36].

The soils in months of January- March had a prevalence of 52.9% while 47.1% prevalence was recorded between the months of April-June. This could be as a result of the moderate temperature and high organic contents of the soils in the months of January- March when compared to that of April-June (Fig. 1). While between the months of April-June, There was a slight decrease temperature and organic content which may have affected the number of organisms recovered. This finding is equally in agreement with [37] who recorded a prevalence of (18.7%) and (12.0%) respectively these months.

During the study period, Loamy soils had the highest prevalence of 64.5% of the organisms while clayey soils had the lowest prevalence of 8.5%, this could be attributed to physico-chemical parameters of Loamy soils which though were almost same with those of sandy and clayey soils had a higher organic content. It was equally observed that there was an increase in prevalence geohelminths in the soil types with an increase in the physico-chemical parameters. This is in line with the findings of Samia et al. [35].

Sandy and loamy soils are equally preferred by animals and indeed humans for defecation as they have loose texture for them to burrow their faeces deeper into the soil. Also, soil transmitted helminths eggs have been found to survive more in sandy soils, with high silt content, since they provide aeration and moisture for their development [9]. Clay soil had a very low prevalence which according to [36,33] may be as

a result of clayey soils not providing enough oxygen needed for soil transmitted helminthes egg development and are believed to prevent egg dispersal by water.

This agrees with the findings of [38] who reported that there is no direct relationship between soil texture and the prevalence of helminthes eggs in soil even though physical properties of soil do influence survival of eggs in the soil. The high prevalence of *Ascaris lumbricoides*, *Trichuris trichiura* and *Meloidogyne* spp, in this study may be as a result of them thriving under different levels of physico-chemical parameters and soil types. Other studies in southern Nigeria stated that the high prevalence of the organisms may be as a result of their eggs being very resistant to harsh environmental conditions and can remain in the environment for longer period [39,40]. This result is also in line with results obtained by [41] in Anambra State eastern Nigeria and [25] in Rivers State. *Trichuris* spp prevalence of 19.5% was a bit higher when compared with reports from studies in other parts of the country which reported *Trichuris* prevalence to be 14.0% [40]. Hookworm had a prevalence of 12.3%, this result is low compared with the values from other studies in various parts of the country which reported 22.5%, 58.3%, 29% and 31.1% [1,42,43]. Table 3 indicates the parameters used in the study, Soil temperature mean $27.2^{\circ}\text{C} \pm 5.2$ S.D, soil pH mean 6.3 ± 2.5 S.D and soil organic matter mean $12.7\% \pm 3.6$ S.D, clay soil mean 16 ± 3.5 S.D, loam soil mean 115.5 ± 10.7 S.D and sandy soil mean 47.5 ± 6.9 . Loamy soil had highest number of 233 samples, sandy soil had 95 samples, and clay had 32 samples. However, from the results the different parameters had some effect in the distribution of geohelminths.

5. CONCLUSION

An increase in the physico-chemical parameters of the soil samples especially the organic content lead to an increase in the abundance of geohelminthes in the various sites therefore combination of sanitation and community health education is a necessary and effective control measure of geohelminths. Sanitation by building of functional and accessible faecal disposal facilities that is suitable to the local conditions, as the only sure way of eradicating geohelminths especially those of public health importance remains the non deposition of human and other animal waste directly into the soils.

6. RECOMMENDATIONS

- i. The communities should be enlightened on the dangers of open defecation.
- ii. The Government should reintroduce sanitary inspection of our environment to check the indiscriminate and unhygienic disposal of human waste.
- iii. Further studies should be carried out especially on children in the area to ascertain the level of geohelminths prevalence in humans.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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