

Rate of Soil Contamination by Soil Transmitted Helminths in Relation to the Awareness Status of Pupils in Primary Schools of Penka-Michel, West-Cameroon

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Abstract: *Background:* Soil transmitted helminth (STH) infections disproportionately affect poor populations in tropical and subtropical parts of the world. They contaminate soil and pupils are mostly at risk of these infections due to their soil related habits. *Aims:* to assess pupils' knowledge, attitude and practice in relation to the rate of soil contamination in public primary schools. *Methods:* Structured questionnaires were administered to 729 consenting participants to obtain information on their awareness status of STH infections. A total of 552 soil samples were collected around toilets, classrooms backyards and playground in 23 public schools randomly selected in Penka-Michel subdivision and examined for the presence of STH eggs using the sucrose flotation method. *Results:* up to 80% of respondents do not actually know how to avoid getting infected with worms. About 50% of pupils do not actually wash their hands after defecating or wash their fruits/vegetables before eating. Pupil's nails were mostly untrimmed (74.1%). 77.1% declared they always defecate out of the toilets when they are in school. Out of 552 soil samples examined, 97 (17.6%) were contaminated by *Ascaris* sp, *Trichuris* sp, *Toxocara* sp, *Capillaria* sp, *Cooperia* sp, hookworms and *Nematodirus* sp. Soil from around toilets were significantly more contaminated with *Ascaris* sp and *Trichuris* sp eggs. Soil contamination was also significantly associated with absence of water during class hours, unhygienic conditions of toilets, and lack of school perimeter fence. Overall 65% of schools selected showed a low level of hygiene. *Conclusion:* Pupils of these schools played a major role in the contamination of their environment. Therefore, in order to prevent the STHs transmission cycles in school environment and possibly in pupils, it is necessary to develop specific sustainable intervention programs.

Keywords: Soil Transmitted Helminth, Pupils, Awareness, Soil Contamination, Penka-Michel

1. Introduction

Soil is a potential source of human diseases caused by many helminth parasites. Soil-Transmitted Helminth (STH) infections are among the most prevalent of chronic human infections worldwide and their distribution is closely related to climate and soil characteristics [1]. Moreover, higher

prevalences are found in tropical and sub-tropical regions, especially in developing countries where their persistence is associated to poverty, lack of potable water, inadequate, or inexistent sanitary facilities, poor hygiene, and inefficient health services [2-4]. It is estimated that, more than 2 billion people, (24%) of the world's population are infected by STH such as *Ascaris lumbricoides*, hookworms, and *Trichuris*

trichiura [5]. Epidemiologically, there is no target age with STH infection, but due to their frequent playing with soil, walking barefoot, poor health, or nutritional status, and geophagic habits coupled with a low level of awareness, the highest rates mostly occur among school-age children living in rural areas [6, 7]. Chronic infections have insidious effects on their growth, intellectual development, and on their school performance, thus increase their vulnerability to other disease. Heavy infections on the other hand may result in serious clinical disease [8]. In addition to the STHs pledged to humans, many other STHs species of domestic and wild animals' origin are now reported to be emerging STH parasitic infectious agent. These include: *Ancylostoma caninum*, *Ancylostoma braziliense*, *Ascaris suum*, *Strongyloides stercoralis*, *Toxocara canis*, and *Trichuris vulpis* [9]. Infection with these parasites could be of public health concern [10]. For instance in humans, *A. caninum* infection may lead to eosinophilic enteritis while *A. braziliense* and *T. canis* can cause cutaneous larva migrans without intestinal infection [11, 12]. These parasites are under-diagnosed due to sundry reasons such as the fact that medical personnel are largely unfamiliar with the identity of such parasites [13]. Although zoonotic and human STH infections symptoms often present very similar clinical pictures, they sometimes require different diagnostic and treatment approaches [14].

Soil plays a crucial role in the life cycle of STH species. Before becoming infective, the ova need to undergo further development through incubation in a warm and moist soil and can be viable in such conditions for several years. Indiscriminate disposal of human and animal faeces are the main sources of soil contamination by STH eggs [15, 16]. This has been confirmed in Philippines, Kenya, Ethiopia, Vietnam, South Africa and Nigeria [17-19].

Improvement in child health and education are key targets in many international development programs, but relatively little is known about the multiple health and educational benefits of integrating different school-based health interventions [20]. In Cameroon, especially in rural area, many public schools lack functional toilet facilities and when they exist, they are mostly non maintained latrine or pit-hole toilets. Due to the high number of pupils in these schools, coupled with lack or few toilet facilities, some pupils defecate around classrooms, around toilets, or in the bushes surrounding the schools. Also, most of these schools lack drinkable water. Focusing on this, there is evidence of fecal environmental contamination which is obviously the way through which pupils may get STHs infections in schools. Based on epidemiological findings, Cameroon adopted in 2004 a strategic plan for the control of STHs and since 2007, routine annual Mass Drug Administration (MDA) has been implemented nationwide to both enrolled and non-enrolled school aged children in order to reduce prevalence and associated morbidities [21]. But soil contamination by STH eggs or larvae in school environments is understudied. This study was therefore designed to assess pupil's knowledge, attitude, and practices with respect to rate of soil

contamination in selected primary schools of Penka-Michel subdivision, Western-Cameroon in order to highlight predicting factors associated to soil contamination in school environment and guide intervention programs aimed at limiting risk of infection in pupils.

2. Material and Methods

2.1. Study Location and Sampling Sites

This cross-sectional survey was carried out in Penka-Michel Subdivision of the Menoua Division, West Region of Cameroon (Figure 1). Penka-Michel is located between latitude 21.52, 5° and 31.41, 5° north of the equator and longitude 7.39, 10° and 20,10° East of the Greenwich Meridian, at an altitude of about 1500 m above sea level. The locality experiences two distinct seasons: a short dry (November to March) and a long rainy season (March to November). The highest rainfall registered in a year could reach 345.1 mm and the thermal amplitude between the hottest month of the year (March: 21.5°C) and the coldest (August: 18.9°C) is 2.6°C. Penka-Michel is a rural area made up of four villages (Balessing, Bamendou, Baloum and Bansa) with an estimated population of about 124 880 people of which 'Bamilikés' constitute more than 90% of inhabitants [22]. Penka-Michel has 64 Public and 23 private primary schools.

2.2. Study Design

Twenty-three (23) government primary schools out of the sixty-four (64) found in Penka-Michel subdivision were randomly selected for this study. This was done by writing the name of each school with respect to their village on a separate piece of paper, then placed in four boxes (representing the 4 villages) and thoroughly mixed before selection by blindly picking the pieces of paper. As result 23 schools were selected: 6/23 in Bamendou, 6/23 in Bansa, 6/11 in Balessing and 5/7 in Baloum (Figure 1).

2.3. Ethical Approval

Permission to carry out the investigation was granted by West regional delegate of public health, public health officers of Penka-Michel district and authorities in charge of basic education in Penka-Michel. Voluntary participation and withdrawal from the study at any time without repercussion were ensured. All data/information on participants from the completed questionnaire were kept confidential to prevent undue access by any third party.

2.4. Administration of Questionnaire

A structured questionnaire was administered to each participating pupil aged from 4 to 14 years. The questionnaire was designed to collect information on personal bio-data on their attitudes and practices, on characteristics of their homes as well as their perception and knowledge on soil transmitted infections. Especially, young

pupils of 4 to 7 years old and others were assisted by their brothers of other classes, by their teachers or by the head of school in completing the questionnaire and where necessary, questions were translated in dialect for better understanding.

The sample size of participants for the study was calculated using prevalence 52.8% of STH reported by Tchuem Tchuente *et al.* [23] among pupils in southern Cameroon, applying the following formula:

$$n = \frac{(Z_{1-\alpha/2})^2 \cdot P(1 - P)}{d^2}$$

Where; n=the expected sample size, p=prevalence of STH infection in school children from previous studies ($P=0.528$), $d=5\%$ (margin of error) and $Z_{1-\alpha/2}=1.96$ at 95% confidence interval (CI). This gave a sample size of 382.95 pupils. Thus minimum sample size of 383 participants was expected for the study. Finally, due to their massive participation, 729 pupils were enrolled for this study.

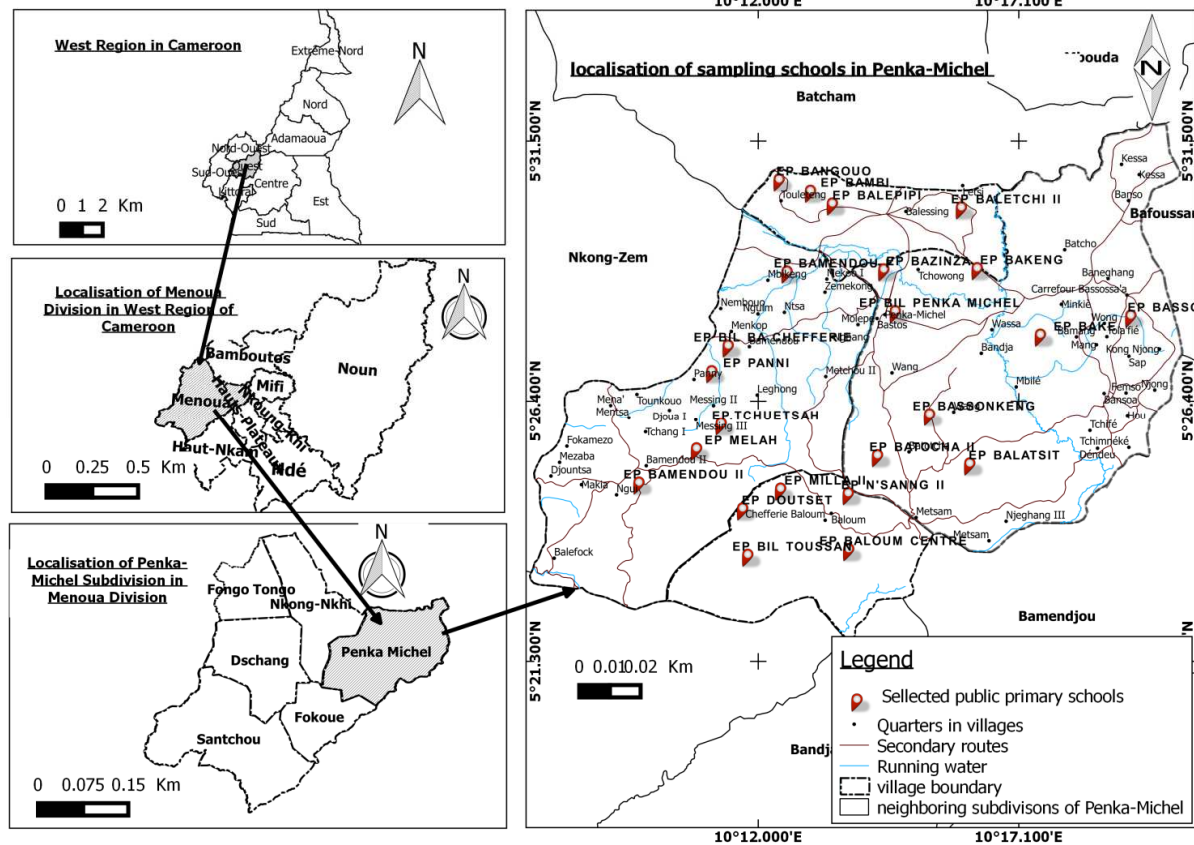


Figure 1. Study area and selected government primary schools in Penka-Michel Sub-subdivision.

2.5. Scoring Hygienic Condition of the Selected Schools

School's hygienic conditions were assessed through visual inspection [24]. This was done spontaneously during unannounced visits in selected schools. A total of 10 criteria were used to calculate the school hygienic score. For criteria with yes or no answer, a value of 1 or 0 was assigned respectively. For criteria with three possible outcomes, a value of 0.5 was assigned to the intermediate outcome. Once the score was calculated, the variable was dichotomized using an arbitrary cut-off value of 6.0. Schools scoring below 6 were categorized as with low hygienic level.

2.6. Soil Sample Collection and Analysis for the Detection of STH Eggs

Five hundred and fifty-two (552) soil samples were

collected from September 2019 to February 2020 in the randomly selected 23 primary schools. Once in these schools, quadrat (Systematic unaligned sampling) or transect (Walking path transect sampling) was drawn at random on the selected sites and trowel was used to collect approximately 100 g of soil at a depth of 2–3 cm of topsoil from each quadrat or transect area [25, 26, 1]. Quadruplicate topsoil samples were taken from three ecologically relevant spots in the school. These were the playgrounds, classrooms backyards and toilets surroundings or defecation sites. Samples were kept in polythene bags, tied, and well labeled, then taken to the Research Unit of Applied Biology and Ecology (RUBEA) of the University of Dschang for analysis.

The soil samples were analyzed using the sucrose floatation technique as described by Uga *et al.* [27]. In the laboratory, each soil sample was sieved with a 150µm sieve to remove

large particles. Two grams of powder were weighed and put in a test tube and mixed with 8ml of distilled water. After centrifugation at 1000 rpm for 5min, the supernatant was discarded and the pellet rediluted with 8ml of sucrose solution (1.20). The mixture was vigorously shaken and centrifuged at 2000 rpm for 10 min. Finally, the interface and the upper layer obtained were collected and introduced into 3 test tubes until the formation of the upper meniscus. Three cover slips were carefully placed above the tubes. After 10 minutes, cover slips were removed carefully and placed on 3 slides and observed microscopically at 10x and 40x. The identification of eggs was done using morphological and morphometrical characteristics such as the size, shape, nature of the shell and the egg contents [28, 29]. The number of eggs per gram of soil was calculated from the equation $N=A.X/P.M$ where A is the mean counts from the slides, X the volume of the final product (ml), P the estimated meniscus volume (ml) and M the mass of the initial sample (2 g).

2.7. Statistical Analysis

Data were stored in Microsoft Excel Spread Sheet 2007 and analyzed using Statistical Package for Social Sciences (SPSS) version 22 and MedCalc online version 14.8.1 statistic software. Descriptive analysis was performed on the data and the results presented in tables and graphs. Statistical tests were carried out at 95% confidence interval. The data was tested for normality using the Kolmogorov-Smirnov test. Mean parasite egg densities of soil sampling sites were compared using non-parametric Kruskal-Wallis test (H) or the Mann-Whitney U test (W) as seen appropriate. Chi square (χ^2) test was used to compare soil contamination rate.

Table 1. Demographic characteristics of pupil subjected to KAP surveys for soil transmitted helminthes.

Variable	Categories	Frequency (%)
Sex	Male	382 (52.4)
	Female	347 (47.6)
Age (years)	4-7	175 (24.0)
	8-11	499 (68.4)
	12-14	55 (7.5)

3. Results

3.1. Demographic Characteristics of Respondents

All the 23 government primary schools selected participate in the study. In these schools, a total of 729 willing pupils (382 (52.4%) boys and 347 (47.6%) girls) participated in the study in the four villages of Penka-Michel Subdivision. The highest (68.4%) and lowest (7.5%) proportion of respondents were within the age range of 8–11 years and 12–14 years respectively. While a quarter (24%) were aged 4 to 7 years (Table 1).

3.2. Awareness Status of STH Among Respondents

Approximately 44.3% of enrolled pupils have knowledge of parasitic worms. However, 85.6% do not actually know

how to avoid getting infected with worms (Table 2). A large proportion of the respondents (83.7%) indicated that they occasionally received anti-helminthic drugs. A total of 325 (44.6%) walk barefooted while 48.1% of the respondents kept cat, pig and dog as pet animals. Their main source of drinking water was stream (81.2%) followed by bore hole water (16.0%). Some of the enrolled pupils used pit toilet (34.0%) and also a large proportion (49.7%) do not actually wash their hands after defecating/before eating or wash of fruits/vegetables before eating. Pupil's nails were mostly untrimmed (74.1%) while 77.1% affirm always defecate out of the toilets when they are in school.

Table 2. Pupil's knowledge, attitude and practices towards STH infection.

Parameters	Frequency (%)	χ^2	P-value
Knowledge on STH		9.340	0.002
Yes	323 (44.3)		
No	406 (55.7)		
prevention of STH		244.934	< 0.001
Yes	105 (14.4)		
No	624 (85.6)		
Deworming Frequency		227.590	< 0.001
Regular	119 (16.3)		
Occasionally	610 (83.7)		
Source of drinking water at home		771.218	< 0.001
Well	20 (2.7)		
Boring	117 (16.0)		
Stream	592 (81.2)		
Type of toilet at home		472.255	< 0.001
Absent	1 (0.1)		
Pit toilet	248 (34.0)		
Latrine	480 (65.8)		
Ownership of pets/animals		1.050	0.305
No	378 (51.9)		
Yes	351 (48.1)		
Walking barefooted		42.172	< 0.001
No	193 (26.5)		
Sometimes	211 (28.9)		
Always	325 (44.6)		
Hand washing after defecating/before eating		221.209	< 0.001
No	311 (42.7)		
Sometimes	362 (49.7)		
Always	56 (7.7)		
washing of fruits/vegetables before eating		95.366	< 0.001
Always	197 (27.0)		
Sometimes	166 (22.8)		
No	366 (50.2)		
Nail biting		137.319	< 0.001
Trimmed	189 (25.9)		
Untrimmed	540 (74.1)		
Open defecation		628.172	< 0.001
No	85 (11.7)		
Sometimes	82 (11.2)		
Always	562 (77.1)		

3.3. Soil Transmitted Helminths and Their Contamination Rate and Concentration Levels

Out of 552 soil samples examined, 97 (17.6%) were contaminated with at least one or more soil transmitted nematode eggs. These eggs were identified to the genera *Ascaris*, *Trichuris*, *Capillaria*, *Toxocara*, *Cooperia*, *Nematodirus* and hookworms (Table 3). Those of the genus

Ascaris and *Trichuris* were the most frequent followed by the genera *Toxocara* and *Capillaria*. The average concentration of these eggs in soil samples expressed in terms of eggs per gram of soil (mean±standard deviation) also varied from one

genus to another. High concentrations of eggs in soil were recorded with *Ascaris* sp (15.01±14.97), *Toxocara* sp (8.75±3.03), *Trichuris* sp (8.40±3.79) and *Capillaria* sp (7.18±2.56).

Table 3. Soil contamination rate and concentration levels of soil transmitted eggs in soil samples in selected primary schools during survey.

Soil transmitted helminthes	Number of soil sample examined	Number of positive soil sample	Contamination rate (%)	Soil egg concentration±SD eggs/g of soil
<i>Ascaris</i> sp	552	49	8.9	15.01±14.97
<i>Trichuris</i> sp	552	24	4.3	8.40±3.79
<i>Toxocara</i> sp	552	14	2.5	8.75±3.03
<i>Capillaria</i> sp	552	13	2.4	7.18±2.56
<i>Cooperia</i> sp	552	2	0.4	5.83
Hookworm	552	1	0.2	5.83
<i>Nematodirus</i> sp	552	1	0.2	5.83

3.4. Village – Related Soil Contamination Among Selected Government Primary School

Four groups of schools literally stand out in the 4 villages surveyed (Figure 2). The first group consists of schools free of soil-transmitted helminth eggs. These include Balepipi and Bambi government primary schools in Balessing and Penka-Michel government bilingual school in Bansoa. The second group consists of schools which presented only one genus of soil-transmitted helminth eggs, those of *Toxocara* sp, *Ascaris* sp, *Trichuris* sp and *Ascaris* sp observed in Bangou government primary schools in Balessing and Bamendou I in Bamendou and the Bake and Blatsit government schools in Bansoa respectively. The third group is made up of schools with significant diversity of soil-helminth egg genera. This is

the case of Baletchi II and of Bazinza government primary schools in Balessing, Milla II and Doutset government primary schools in Baloum, Melah and Bamendou chiefdom government bilingual primary school, Bassonkeng and Batocha government primary schools in Bansoa. The fourth group is made up of schools whose soil contamination rate by certain type of nematode genera eggs was higher than the general contamination rate (17.6%). These include not only *Ascaris* sp with 20.8%, 25% and 25% recorded in Baletchi II in Balessing, Melah in Bamendou and Baloum center government primary schools respectively, but also *Toxocara* sp eggs with 29.2% in Tcheutsah government primary school in Bamendou. In addition, irrespective of the village, eggs of the genus *Ascaris* were more frequent except in Tcheutsah, Milla II and Batocha I government primary schools.

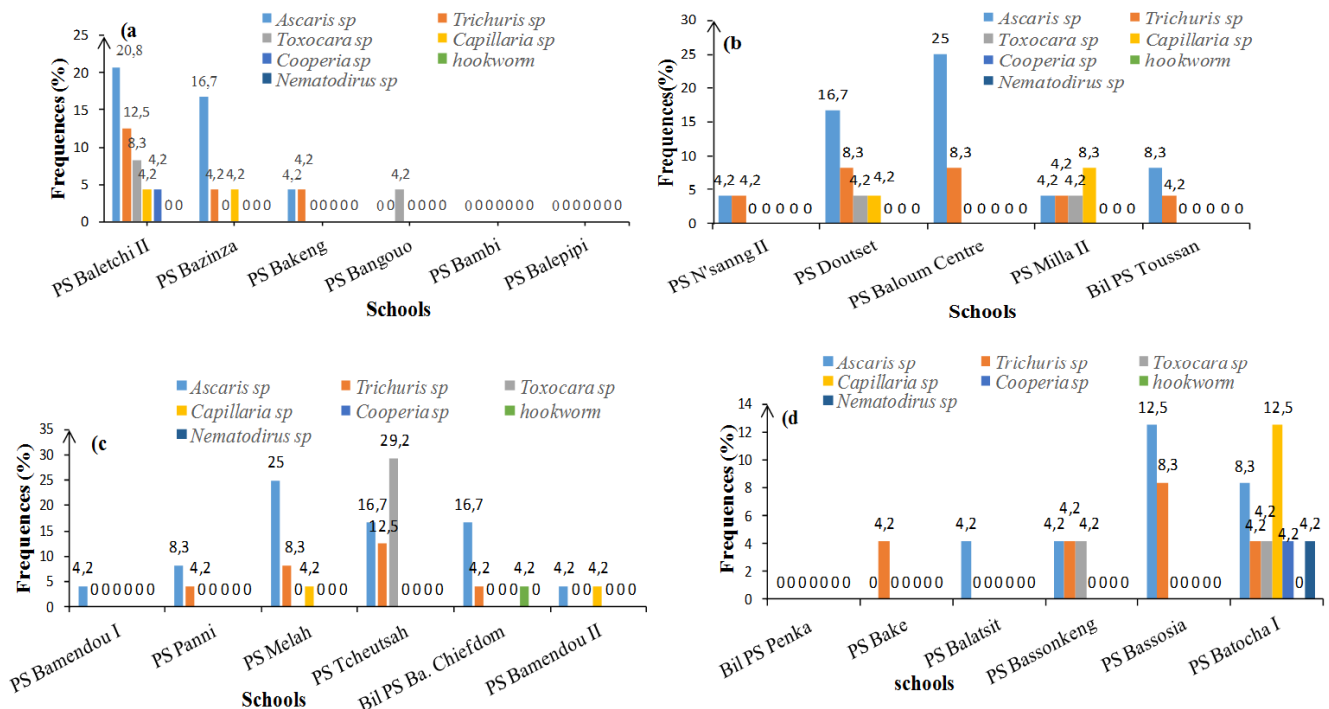


Figure 2. Distribution of soil transmitted nematode genera among government primary schools: a) Balessing, b) Baloum, c) Bamendou and d) Bansoa.

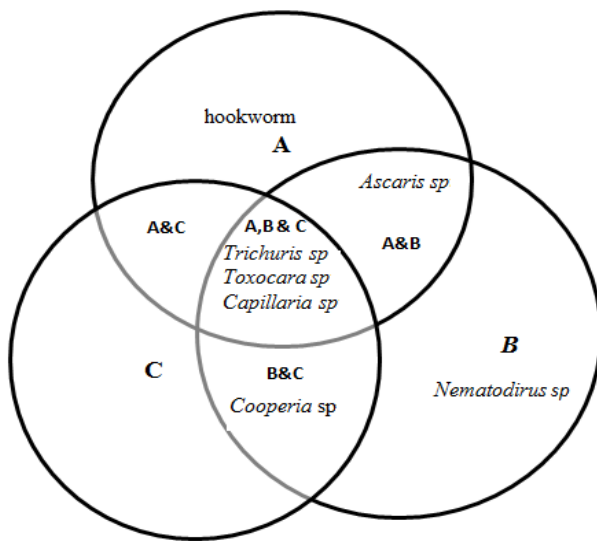


Figure 3. Distribution of identified soil transmitted helminth eggs among the sample sites: A=around toilets, B=classroom backyards and C=playgrounds.

3.5. Distribution of Soil Transmitted Nematodes Among the Soil Sampling Sites

The nematode eggs identified were not uniformly distributed among the three soil sampling sites (Figure 3).

This diagram reveals three very different ecological groupings based on their geohelminth egg composition: groups A and B potentially rich and specific to hookworm and *Nematodirus* sp egg respectively; The sharing groups A&B and B&C potentially rich and specific to *Ascaris* sp and *Cooperia* sp eggs respectively; group C and sharing groups A&C rich but devoid of specificity in type of helminth egg.

3.6. Site – Related Contamination Rate and Soil Concentration of Soil-transmitted Helminth Eggs in Soil Samples

The contamination rate and soil concentration of soil-transmitted helminth eggs varied among the three sampling sites (table 4). It appears that the contamination rate from around toilets was significantly ($p < 0.001$) higher (12.3%), than that from classroom backyards (3.8%) and that from playgrounds (1.4%). *Ascaris* sp (7.8%) and *Trichuris* sp (3.6%) eggs were significantly ($P < 0.001$) more frequent around toilets than to classrooms backyards and in pupil playgrounds. Indeed, average concentration of identified eggs did not vary significantly ($P > 0.05$) between contaminated soil samples from one site to another.

Table 4. Variation of contamination rate and soil concentration of soil-transmitted helminth eggs among soil sampling sites.

parasites	Sites								
	Around toilets		Classroom backyards		Playground		Total N (%)	C. R P-value	S. E. C P-value
	¹ C. R N (%)	² S. E. C egg/g of soil	C. R N (%)	S. E. C egg/g of soil	C. R N (%)	S. E. C egg/g of soil			
<i>Ascaris</i> sp	43 (7.8) ^a	15.74±15.82	6 (1.1) ^b	9.72±3.01	0 (0.0) ^b	-	49 (8.9)	0.001	0.361
<i>Trichuris</i> sp	20 (3.6) ^a	8.61±3.96	3 (0.5) ^b	5.83±0.0	1 (0.2) ^b	11.67	24 (4.3)	0.001	0.261
<i>Toxocara</i> sp	4 (0.7) ^a	9.72±3.37	7 (1.3) ^a	8.33±3.12	3 (0.5) ^a	8.75±3.37	14 (2.5)	0.395	0.820
<i>Capillaria</i> sp	5 (0.9) ^a	5.83±0.0	4 (0.7) ^a	7.29±2.92	4 (0.7) ^a	8.75±3.37	13 (2.4)	0.926	0.235
<i>Cooperia</i> sp	0 (0.0)	-	1 (0.2)	5.83	1 (0.2)	5.83	2 (0.4)	0.133	-
ankylostomes	1 (0.2)	5.83	0 (0.0)	-	0 (0.0)	-	1 (0.2)	0.367	-
<i>Nematodirus</i> sp	0 (0.0)	-	0 (0.0)	-	1 (0.2)	5.83	1 (0.2)	0.367	-
Total	68 (12.3) ^a		21 (3.8) ^b		8 (1.4) ^c		97 (17.6)	.000	

¹C. R=contamination rate, ²S. E. C=Soil Egg Concentration

C. R P-value determination: a and b on the same line=significant at $P < 0.05$ - a, a on the same line=non-significant at $P > 0.05$ - a, b and c on the same line=significant at $P < 0.05$

S. E. C P-value determination: no symbols on the same line=non-significant at $P > 0.05$

3.7. Hygienic Scores of Various Primary Schools Sampled

The average hygienic score of sampled schools in the 4 villages were below 6 and therefore low level of hygiene (Table 5). Water and sink facilities whether functional or not were the most absent in these schools. Two types of toilets occurred: the latrines (commonly observed) and the pits. Although present, these health facilities were non-functional in 6 of the 23 schools inspected. The unhealthy surroundings and in the toilets accompanied by fragrant odors from the piles of feces and urine frequently noted in most of these schools strongly impacted their hygienic level. The complete

absence of school perimeter fence in many schools give chance to animals to access the schools.

3.8. Predicting Factors Associated to Soil Contamination by Soil-Transmitted Helminth and Risk of Pupils Infection

Soil contamination in selected schools was significantly ($P < 0.001$) related to sampling sites, the number of pupil enrolled in school, the absence of water during class time, number of toilet, lack of clean toilets both inside and outside, odor control in toilets, absence of sink for hand washing and fence (Table 6).

Table 5. Average hygienic scores in sampled primary schools.

Criteria						
Villages	Water during class hours ^a	Sink with water for handwashing ^b	Clean surroundings classroom area	Type of toilets ^c	Sanitary facilities functional	Clean surrounding toilets areas
Baloum	0.1	0.00	0.60	0.90	0.60	0.20
Bamendou	0.33	0.00	0.83	0.83	0.67	0.33
Balessing	0.25	0.00	0.83	1.00	0.83	0.50
Bansoa	0.42	0.25	0.50	1.00	0.67	0.50

Table 5. Continued.

Criteria						
Villages	Inside toilet clean	Control of toilet odours ^d	School perimeter fence ^e	Animal imprints in school environment	Average hygienic score	Average hygienic level
Baloum	0.20	0.30	0.00	0.60	3.50	low
Bamendou	0.33	0.33	0.08	0.33	4.08	low
Balessing	0.33	0.33	0.17	0.83	5.10	low
Bansoa	0.67	0.33	0.17	0.50	5.00	low

^atape and water; only tape but no water=0,5; ^bSink and water=1; only sink but no water available=0,5

^clatrine=1; flush toilets=0,5; ^dodourless=1, less fragrant=0,5; ^efence with: definitive material=1; local material=0,5

Table 6. Predicting factors associated to soil contamination and risk of pupil's infection.

Variables	N	Frequency n (%) [*]	odd ratio	95% CI	P-value
Sampling sites					
Playground	184	8 (1.4) ^b	1.00		-
Behind classroom	184	21 (3.8) ^b	0.35	[0.15 - 0.82]	0.015
Around toilets	184	68 (12.3) ^a	0.07	[0.04 - 0.17]	< 0.001
Number of student enrolled					
[100-250]	144	24 (4.4) ^{a, b}	1.00		-
[250-400]	216	47 (8.5) ^b	0.71	[0.42 - 1.24]	0.235
>400	192	26 (4.7) ^a	1.27	[0.69 - 2.33]	0.426
Water during class hours					
No	456	81 (14.7) ^a	1.00		-
yes	96	16 (2.9) ^b	1.08	[0.59 - 1.94]	0.797
Type of toilets					
Pit toilets	48	22 (3.9) ^b	1.00		-
latrine	504	75 (13.6) ^a	4.84	[2.60 - 8.98]	< 0.001
Functionality of Sanitary facilities					
No	168	48 (8.7) ^a	1.00		-
yes	384	49 (8.9) ^a	2.73	[1.74 - 4.28]	< 0.001
Number of toilets					
[01-02]	384	89 (16.1) ^a	1.00		-
[03-05]	120	3 (0.5) ^b	11.76	[3.65 - 37.92]	< 0.001
≥06	48	5 (0.9) ^b	0.30	[0.08 - 1.06]	0.062
Clean surrounding and inside toilets areas					
No	360	86 (15.6) ^a	1.00		-
yes	192	11 (1.9) ^b	5.16	[2.68 - 9.94]	< 0.001
Control of odour in toilet					
odourless	168	8 (1.4) ^a	1.00		-
less fragrant	168	18 (3.3) ^b	0.41	[0.17 - 0.98]	0.046
fragrant	216	71 (12.9) ^c	0.10	[0.05 - 0.22]	< 0.001
Sink?					
No	480	89 (16.1) ^a	1.00		-
yes	72	8 (1.4) ^b	1.82	[0.84 - 3.93]	0.127
Gate					
No	456	84 (15.2) ^a	1.00		-
Local material	96	13 (2.4) ^b	1.44	[0.77 - 2.71]	0.255

a and b on the same column=significant at P<0.05 - a, a on the same column=non-significant at P>0.05

a, b and c on the same column=significant at P<0.05. *contaminated soil samples

Among these factors, the best predicting determinant factors associated to soil contamination by STH in schools were the type of toilets, the functionality of these toilets, the lack of clean toilets, and the odour control in toilets. So pupils were at 4.84 [2.60 - 8.98] times exposed to STH

infection in school with pit toilets (p< 0.0001), 2.73 [1.74 - 4.28] exposed in schools with no functional toilets (p< 0.0001), 11.76 [3.65 - 37.92] and 0.30 [0.08 - 1.06] times exposed in schools with 1-2 toilet as compared to those schooled in school with 3-5 and ≥06 toilets respectively.

They were also exposed at 5.16 [2.68-9.94] times to STH infection in school with lack of cleaning surrounding and inside toilets areas ($p < 0.0001$).

4. Discussion

The present study demonstrated that a reasonable proportion of pupils had inadequate level of knowledge on STHs aetiology. As far as preventive methods, attitude and practices are concerned, up to 80% of pupils were unable to provide correct answers regarding STH transmission and prevention. This result may be the consequence of misconception of their parent or tutor on STH transmission and prevention as mentioned by [30]. Another misconception can derive from poor basic health educational background on transmission, and prevention of infections teaches in school. These misconceptions and beliefs further undergird the need for comprehensive health education interventions as integral components of STH control in these settings [31].

The overall rate of soil contamination (17.6%) by STH eggs obtained in the present study could be as a result of poor environmental sanitation and poor hygiene habits, reflecting the pupil's behaviour regarding environmental cleanliness and the negligence of this issue by the school staff. Pupils are unaware of environmental contamination risks. So the presence of potentially pathogenic helminth parasites in the school environment exposes pupils to infection. This result was higher than the 7.75% reported by Nkouayep *et al.* [32] in ten primary schools in Dschang, West Cameroon. But less than 26.79% obtained by Ntonifor *et al.* [33] in the Upper Nkongho-mbo Area, South-west Region, Cameroon.

All the STH eggs identified were potential cause of zoonotic diseases except one (*Nematodirus* sp). *Ascaris* sp, *Trichuris* sp and hookworm which have been previously reported elsewhere [32, 13, 34] are of public health importance. *Toxocara* sp, *Capillaria* sp, *Cooperia* sp and *Nematodirus* sp are of animal origin. *Capillaria* sp and *Cooperia* sp were previously reported by Nkouayep *et al.* [32], *Toxocara* sp by Obaid, [35] in other school environments. *Nematodirus* sp are reported here for the first time. The diversity of these STH eggs identified in the present study underlines the low hygienic level frequently observed in the primary schools. This may be due to: 1) the indiscriminate open defecation habits of pupils; 2) lack of perimeter fence which probably favors the presence of large numbers of stray animals (dogs, cats, rodents and ruminants) roaming in these schools.

The presence and survival of nematode eggs in the soil are mostly related to environmental climatic condition and soil characteristics [1]. The rate of soil contamination was the same among villages but significant difference ($p < 0.05$) was obtained among selected schools. It was interesting to observe that floors in some schools were free of STH eggs. This could be the consequence of good practice of hygienic rules by school children under the supervision of teaching staff. Another reason could be the topography of these schools, because placed on a hillside, runoff water

could participate during the rainy season in leaching the soil and thereby cause the STH eggs away from the school site.

Irrespective of village and school, *Ascaris* sp eggs were the most common and predominant among the seven genera of nematode eggs identified. This is in line earlier reports elsewhere [33, 32, 13] and may be explained by the fact that *Ascaris* eggs are resistant to harsh environmental conditions and are laid in rather large numbers given the high fecundity of *Ascaris* (200.000 eggs/day/female) [29] and their high prevalence among pupils [4]. The scanty occurrence of *Cooperia* sp, *Nematodirus* sp and hookworms eggs may be explained by their life cycle and infective form. Once in the environment they quickly hatch into larvae in normal climatic condition within few days or weeks [29].

Contamination rate was highest around toilet area (12.3%) followed by classroom backyards (3.8%). This may be as result of the seclusion of toilets whose unhygienic condition drove pupils to defecate behind classrooms or in surrounding bushes. This open communal contamination of soil with infected faeces thus poses a serious risk to uninfected pupils and also serves as a source of re-infection [34]. In fact, in schools lacking functional toilet facilities, pupils are at high risk of contracting more than one STH species. *Ascaris* sp and *Trichuris* sp eggs were significantly ($P < 0.001$) more common around toilets. This is in agreement with the findings of Omotola, [19] in Nigeria and Nkouayep *et al.* [32] in Cameroon. It seems clear that instead of using toilets some pupils usually defecate around/behind toilets and behind classrooms.

The hygienic level of schools was generally low, in this study could promote fecal contamination of school environment with helminth eggs from infected pupils or stray animals [12].

Almost all hygienic criteria considered were highly related to soil contamination except the type and functionality of toilet. Among these criteria all those related to unhygienic condition of toilet were identified as important predictors of STH infection. So Contamination of the school environment with infective stages of STHs is considerable in the absence of adequate sanitation [36, 37].

5. Limitations

Enormous material and logistical efforts were made to collect the data for this study. We are really satisfied with the relevant results obtained because they fill some gaps in knowledge of awareness status of pupils in the selected public primary schools in Penka-Michel on transmission and prevention of STH and soil contamination rates by STH in their school.

Collecting similar information's in households in relation to the perception of their parents or guardians will be considered in our future studies. This in order to reduce some limitations observed during the study.

6. Conclusion

The high rate of soil contamination not only by human faeces but also by other animal faeces observed in the selected schools in the present study coupled with the high proportion of pupil with inadequate knowledge on how to prevent transmission of STH poses a high risk of STH infection in pupil. Therefore, there is a need for proper education on parasite transmission in public primary schools. We also recommend that there should be significant improvement in the sanitary/water facilities in public primary schools. Continuous education/enlightenment program that strongly emphasise strict compliance to personal and environmental hygiene should also be developed and implemented. Full identification of STH involved and their zoonotic nature should be investigated.

Conflict of Interest

The authors declare that they have no competing interests.

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