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Biodiversity of the infective forms of intestinal parasites in some waste disposal areas in the municipality of Yaounde III -Center Region of Cameroon

KOGA Mang'Dobara[1*], MAMBOUNE Sylvie Martine[1], MAHOB Raymond Joseph[1], AJEAGAH GIDEON Aghaindum[2]

1: University of YAOUNDE I, Faculty of Science, Laboratory of Parasitology and Ecology, PO Box 872
2: University of YAOUNDE I, Faculty of Science, Laboratory of Hydrobiology and Environment

Corresponding author: KOGA Mang'Dobara, mangdobarakoga@gmail.com
Telephone: +237(697759347/670682631)

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Abstract: Intestinal parasites remain a significant public health problem in the tropic and subtropical regions of Africa in particular, and the world in general. This study is aimed at investigating the biodiversity of intestinal parasites in some selected waste disposals of the Efoulan District in the third municipality of Yaounde, Cameroon. Fifty soil samples were collected from five different waste disposal sites and analyzed with adequate methods The biological parameters of the soil were determined using a sedimentation method outlined by Ritchie (1948). Physicochemical parameters of the soil (Temperature, Hydrogen potential, Electrical conductivity, and Total dissolved solids) were assessed in each sampling station, using a four in one Soil survey instrument. Results of the biological analysis of soil samples revealed that, all the collected samples were infected; at least 20 parasite species were identified, and Nematoda was the most diversed group, with at least five species; *Strongyloides stercoralis* was the most prevalent helminth species (56 ± 13.76 %) , and *Cryptosporidium* spp (74 ± 12.16 %), the most common protozoa species; station D exhibited exhibited the highest parasitic load (537.5 parasites) while station E shown the lowest abundance (232.5 parasites). The evaluation of physiochemical parameter shown that temperature varied from 23 °C to 30°C, pH oscillated from 6.4 to 7, the Electrical conductivity fluctuated from 860 µS/cm to 1068 µS/cm and the Total Dissolved Solids varied from 375 mg/L to 534 mg/L. Among the physicochemical parameters of the soil, only temperature presented a positive correlation (rs=0.900) with the number of parasites. These findings emphasize the need for improved sanitation, health screenings, and community education to mitigate infection risks and reduce the prevalence of intestinal parasitic infections in the community.

Keywords: Biodiversity, *Cryptosporidium* spp, Helminths, Intestinal parasites, Protozoa, *Strongyloides stercoralis*.

I.INTRODUCTION

Parasites are highly sensitive to their surrounding environments, which profoundly impact their life cycles, transmission rates, and evolutionary traits. Environmental changes such as climate shifts, pollution, and habitat alteration can radically disrupt these delicate ecological balances, either escalating or reducing the spread of parasitic diseases. Understanding the dynamics between ecosystems and parasites is vital for public and ecological health (Ferreira et al., 2020). Intestinal parasitic infections (IPI) refer to diseases caused by parasites that primarily affect the gastrointestinal tract of both animals and humans (Haque, 2007). These parasites are broadly classified into two main categories which are protozoa and helminths. Intestinal protozoa are single-celled organisms, such as *Giardia* Stiles, 1902, *Cryptosporidium* Tyzzer, 1907, and *Entamoeba histolytica* Fritz,1903 which typically have simple life cycles requiring only one host (Haque, 2007). In contrast, helminths are multicellular parasitic worms, including nematodes (roundworms) and platyhelminths (flatworms, including tapeworms). These parasites often have complex life cycles involving multiple hosts (Benesh et al., 2021). IPI are a significant public health concern in many developing countries, including Cameroon, affecting an estimated 3.5 billion people globally, with approximately 450 million showing clinical symptoms (Belete et al.,2021). In 2004, a report by Cameroon's Secretary of State for Public Health stated that the country's population was estimated at 16.1 million, a substantial number of infections occurs in low-income regions, where factors such as inadequate sanitation and limited healthcare access exacerbate the issue. In such areas, individuals are often infected with multiple parasites simultaneously, a condition known as polyparasitism (Oyono et al., 2019). The effects of these infections can be severe, leading to significant morbidity and mortality, particularly in regions where parasites are endemic (Ahmed et al., 2015). In many tropical and subtropical regions, the hot and humid climates provide ideal conditions for the transmission of these parasites. Geohelminths, which include species such as *Ascaris lumbricoides* Linnaeus, 1758, *Necator americanus* Stiles, 1902, *Ancylostoma duodenale* Dubini, 1843, and *Trichuris trichiura* Linnaeus, 1771, are among the most common human infections worldwide, and protozoa species such as *Giardia duodenalis* Van, 1681 and *Entamoeba histolytica* Fritz, 1903 infect about 200 to 500 million people respectively with over a quarter of the world's population being infected (Darke et al., 2000). While these diseases are frequently associated with rural areas, they also thrive in urban environments with poor sanitation and the poor disposal of faecal matter.

Urbanization in developing countries, such as Cameroon, often leads to uncontrolled population growth, disorganized housing, and the rise of unplanned slums. These conditions, characterized by overcrowding, inadequate sanitation, and poor hygiene practices, create environments conducive to the transmission and persistence of parasitic diseases (Kuete et al., 2015). Rapid urbanization further exacerbates the problem by increasing the risk of parasitic infections, especially in low-income urban areas where infrastructure is lacking and healthcare access is limited. The transmission of intestinal parasites is largely driven by environmental factors, such as soil contamination with peri-faecals, poor sanitation, inadequate water supply, and consumption of raw or undercooked food (Ferreira et al., 2020). In tropical regions, where untreated sewage is often discharged into freshwater sources, people are frequently exposed to contaminated soil, further increasing the risk of infection. People of all ages are exposed to IPIs; however, children are particularly vulnerable to these infections due to their undeveloped immunity, limited awareness of hygiene, and higher nutritional needs, which make them more susceptible to the adverse effects of parasitic diseases (Ahmed & Abu-Sheishaa, 2022).

The distribution and prevalence of intestinal parasites vary across regions, depending on environmental, socioeconomic, and geographical factors (Chala, 2013). Thus, studying the prevalence of IPIs is essential for developing effective control strategies and assessing the risks faced by vulnerable communities (Nasari et al., 2009). Clinically, intestinal parasitic infections can be present with a variety of symptoms, including abdominal cramps, vomiting, nausea, diarrhea, fever, anemia, malabsorption, and itching (Botero et al., 2003). In an effort to control these infections, particularly among school-aged children, the World Health Organization (WHO) recommends preventive chemotherapy using albendazole or mebendazole for geohelminthiasis and praziquantel for schistosomiasis. However, while these treatments reduce the parasitic burden, they do not prevent reinfection, highlighting the need for comprehensive public health interventions to achieve sustainable control (Djieukap-Njieyap et al., 2022).

Warmer temperatures often accelerate the development rates of parasites and increase vector activity, expanding the geographic range of parasitic diseases. Human activities like deforestation, dam construction, and urbanization disrupt food webs. This can concentrate hosts, altering the probability of parasite-host contact. Contaminants and heavy metals can either suppress the immune systems of hosts (making them more vulnerable) or directly affect the parasites themselves. While viewed mostly as detrimental, parasites are essential components of healthy ecosystems: Because they are highly sensitive, shifts in parasite populations can serve as early-warning bioindicators for environmental degradation and pollution. Parasites regulate the population sizes of their hosts, preventing the overdominance of certain species and maintaining biodiversity Brice et al. (2019).

In natural environments, organisms face anthropogenic stressors such as temperature changes, habitat alterations and pollution. Parasites can also be affected by these pollutants. The interactions between parasites and pollutants are diverse, leading to the development of the field of environmental parasitology over the past 30 years. Today, the field has expanded to investigate a

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wide range of anthropogenic stressors and their interactions with parasites, including their combined effects on host health. Environmental parasitology also explores the use of parasites as indicators of pollutants and other environmental changes.

Despite the fact that a number of studies have been conducted on intestinal parasitic infections in Cameroon such as (Brice et al., 2019) in the South Region of Cameroon and Oyono et al. (2019) in the Center Region of Cameroon, there is a scarcity of data on the occurrence of intestinal protozoa and helminths in the Centre Region of Cameroon in general, and specifically in Efoulan District with environmental link. This study aims to investigate the prevalence of the infective forms of intestinal parasites in waste disposal sites in relation to environmental factors in the Efoulan District, Yaoundé III, Center Region of Cameroon.

II. MATRERIAL AND METHODS

II.1. Study area

The study was conducted in Efoulan District, a small locality in the southern part of the city of Yaounde Cameroon, over a period of 6 months, from the 15th February to August 25th 2024. Efoulan is bordered to the East by the Nsam and Dakar, to the North by the catholic mission of Mvolye, to the South by Obobogo, and West by the Nsimeyong (Figure 1). It is situated at an average altitude of approximately 750 meters above sea level, with a geographical coordinate of N3°50'11'' latitude and 11°30'22'' longitude as presented in figure 1.

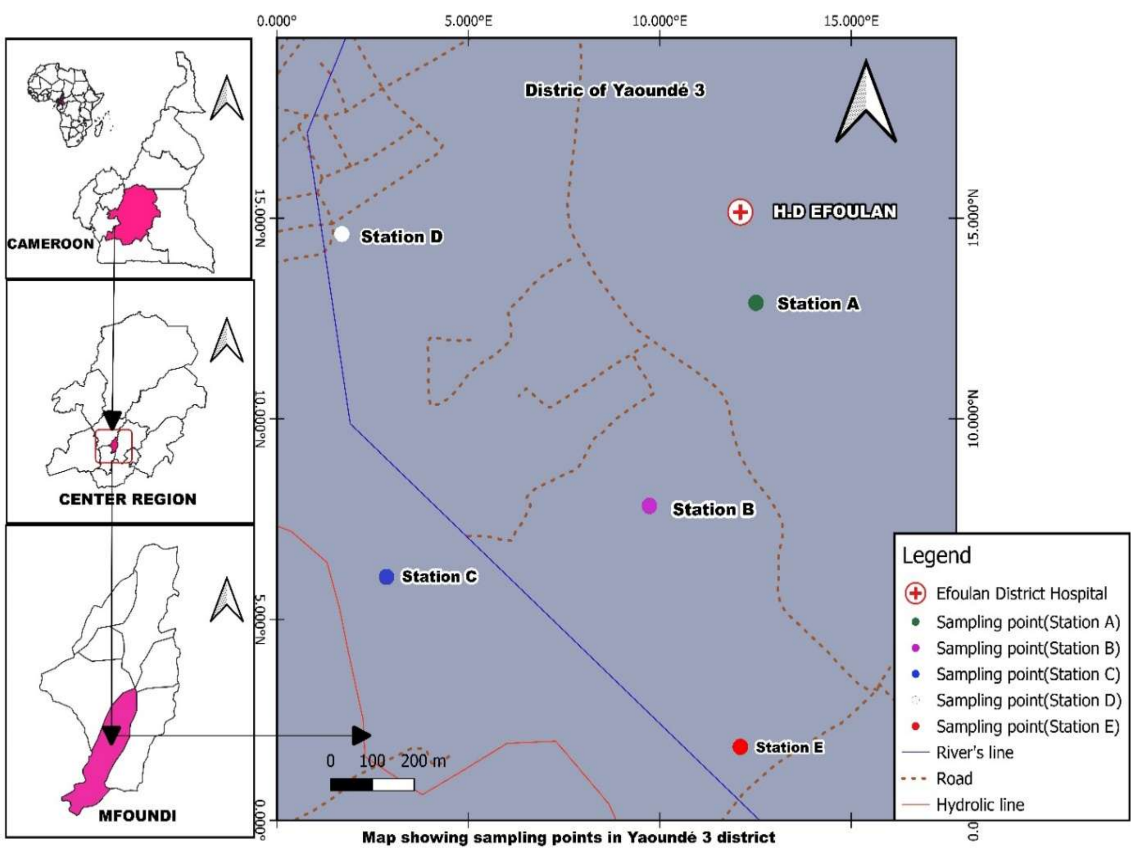

Figure 1: Map of the study area (Open streets Map 2024-QGIS

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II.2. Collection of soil samples

Fifty (50) soil samples were collected in five stations (namely SA, SB, SC, SD and SE) which are all located in Efoulan District (figure2). Soil samples were obtained by scraping the top layer of soil with a spatula. For each station, ten (10) samples were collected, placed in designated plastic containers (Strothmann et al., 2022) and then transported to the Laboratory of Hydrobiology and Environment at the University of Yaoundé I for analysis.

Figure 2: Partial view of the sampling stations during the study period (SA, SBI, SBII, SC, SDI, SDII and SE).

II.3. Assessment of physicochemical parameters of the collected soil samples

Physicochemical parameters which were assessed are: temperature which was measured *in situ* and expressed in degree Celsius (°C); the Hydrogen potential (pH) which was also measured *in situ* and expressed in conventional units (UC); Electrical conductivity (EC), measured in the field and expressed in µS/cm and Total dissolved solids (TDS), measured in the field and expressed in mg/L.

II.4. Assessment of biological parameter of the soil

The biological parameters of the soil were determined using a sedimentation method outlined by Ritchie (1948). Forty (40) grams of each soil sample were mixed with 100mL of distilled water. The supernatant was discarded, and 5mL of the pellet was measured and placed in a test tube, then mixed with 3mL of distilled water. The mixture was vigorously shaken and centrifuged (using a MINOR35 centrifuge) at 300 rpm for 5 minutes. The supernatant was discarded, and the pellet was homogenized using a pipette. A drop of the mixture was taken with the help of a pipette, placed on a slide, and a drop of iodine solution (1%) was added. The solution was covered with a coverslip and examined to identify any infective forms using 10 X and 40 X a binocular optical microscope with 10 X and 40 X objectives to identify any parasites present.

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II.5. Data Analysis

Raw data collected were computerized into Microsoft Excel version 2016 for descriptive analysis. Subsequently, the data were analyzed using Past software version 3.1 and XLSTAT 2024 for inferential analysis. The relationship between physicochemical parameters (temperature, pH, conductivity, and total dissolved solids) and the number of parasites was examined using Spearman's correlation coefficients and corresponding P-values. Positive and negative correlations were recorded, including significant and non-significant ones. All calculations were carried at 5% margin of error.

III.RESULTS

III.1. Inventory of parasites in soil samples

In this study, a total of 50 soil samples were examined, and all of them were found to be infected with one or more parasite species. Results shown that at least 20 parasite species were identified in this study, and Nematoda was the most diversed group with at least 05 species, followed by those of Sporozoa and Flagillata with at least 04 and 03 parasites species respectively, next by those of Amoeba, Cestoda and Trematoda with 02 parasites species each, finally that of Ciliata with only 01 species The most prevalent protozoa species was *Cryptosporidium* spp (74 ± 12. 16%) and the most prevalent helminth species was *Strongyloides stercoralis* (56 ± 13.76%) (Table I). Globally, protozoa were more frequent, comprising 76.29 %, whereas helminth account for 23.71%.

Table I: Inventoried parasite taxa in the soil and their prevalence

Groups	Parasite species	Prevalence (%): ni (Pi ± SE)
Amoeba	*Entamoeba coli*	12 (24 ± 11.84%)
	Entamoeba histolytica	25 (50 ± 13.86%)
Sporozoa	*Cryptosporidium* spp	37 (74 ± 12.16%)
	Sarcocystis spp	30 (60 ± 13.58%)
	Cyclospora cayetanensis	32 (64 ± 13.30%)
	Isospora belli	16 (32 ± 12.93%)
Ciliata	*Balantidium coli*	7 (14 ± 9.62%)
Blastocytis	*Blastocytis hominis*	3(6 ± 6.58%)
Flagillata	*Chilomastix mesnili*	9 (18± 10.65%)
	Giardia lamblia	5 (10 ± 8,32%)
	Retortomonas intestinalis	1 (2± 3.88%)
Nematoda	*Strongyloides stercoralis*	28 (56 ± 13.76%)
	Ascaris lumbricoides	13 (26 ± 12.16%)
	Trichostrongylus spp	3 (6 ± 6.58%)
	Enterobius vermicularis	2 (4± 5.43%)

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	Ancyclostoma duodenale	1 (2± 3.88%)
Cestoda	*Diphyllobothrium latum*	1 (2 ± 3.88%)
	Hymenolepis nana	3 (6 ± 6.58%)
Trematoda	*Schistosoma mansoni*	1 (2 ± 3.88%)
	Fasciola hepatica	3 (6± 6.58%)

ni: number of i parasite species; Pi: prevale nce of parasite species; SE : Standard error

III.2. Parasitic Abundance across soil sampling stations

The evaluation of parasites abundance in the five different stations (A to E) during the study period revealed that Station D shown the highest parasitic loads, with an approximate record of 537.5 parasites and station E exhibited the lower abundance, with around 232.5 recorded parasites (figure 3).

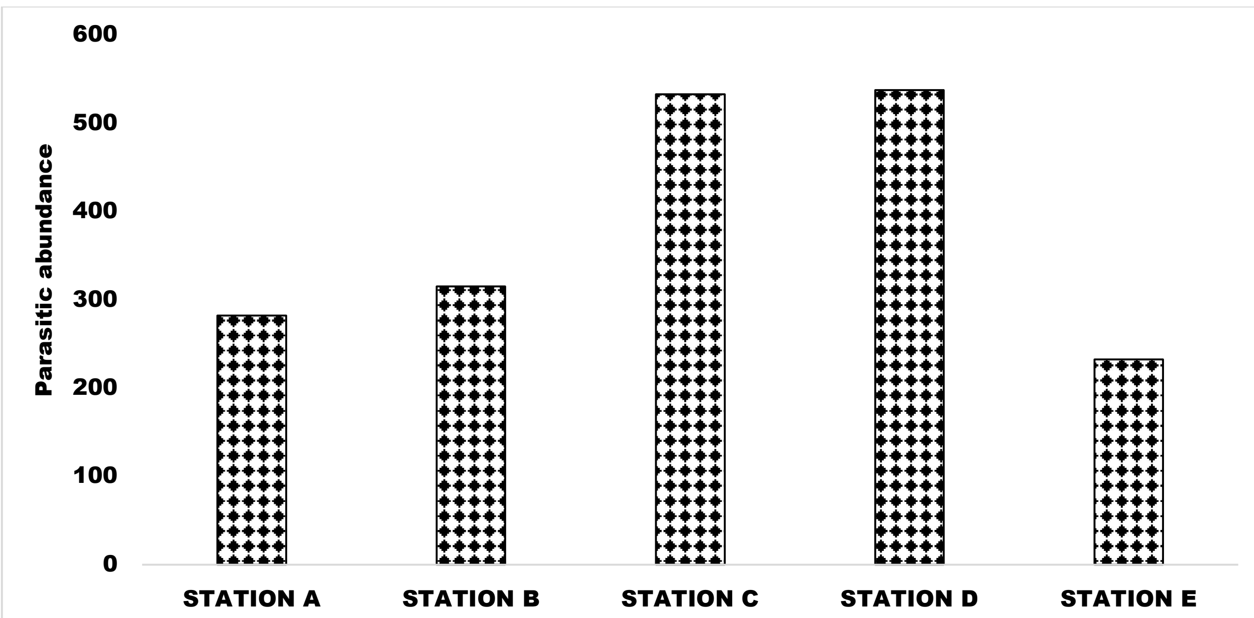

Figure 3: Frequency of parasitic abundance in different studied stations

III.3. Physicochemical parameters of the soil

Results from the measurement of the physicochemical parameters are presented in figure 4. Data revealed that the soil temperature varied from 23°C (station E) to 30°C (station D) with an average value of 26.6 ± 0.99°C; in regard to pH, the values vary between 6.4 in station B and 7 in stations (A, D and E), oscillating around an average value of 6.78 ± 0.1 UC; the electrical conductivity fluctuated from 860µS/cm at station C and E and 1068µS/cm at station A, averaging 887.2 ± 42.07µS/cm; pertaining to the TDS, there is a high value at station A (534mg/L) and a low value at station D (375mg/L), with an average value of 443.6 ± 21.04mg/L.

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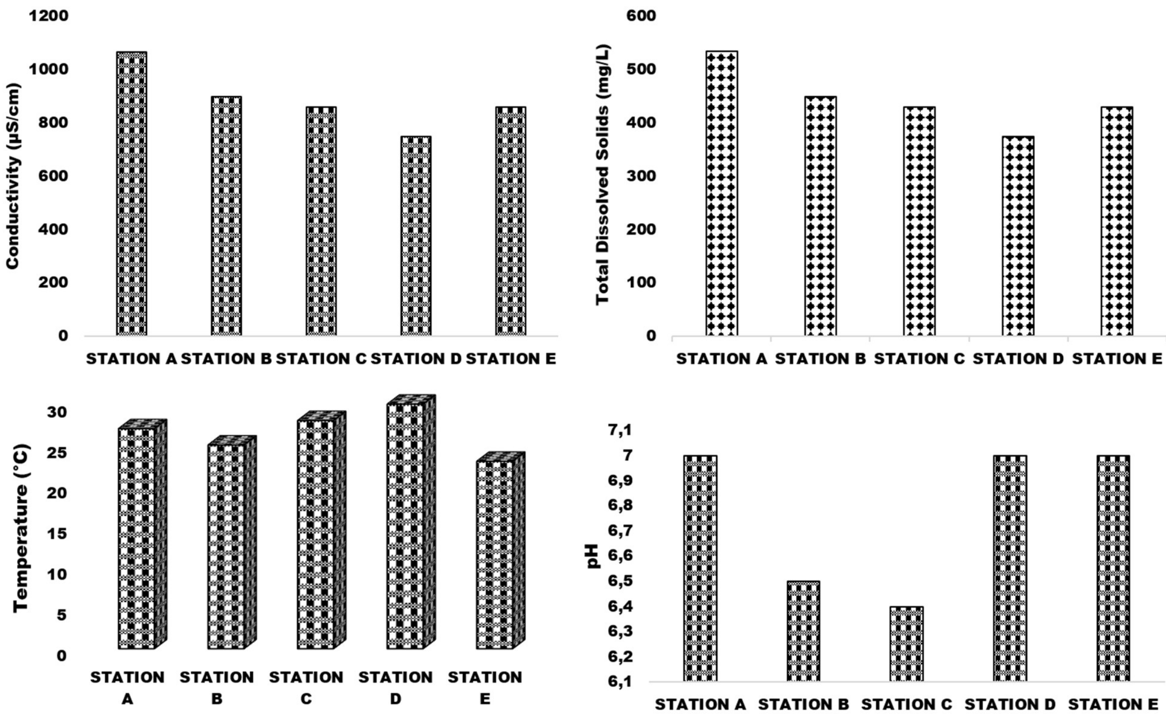

Figure 4: Variation of physicochemical parameters of soil across sampling sites

III.4. Estimation of the correlation between physicochemical parameters and number of parasites

The estimation of the correlation between physicochemical parameters of the soil and the number of parasites revealed a strong positive correlation (rs = 0.900) between the temperature and the number of parasites. However, the P-value (0.083) is greater than 0.05, indicating that, this relationship is not statistically significant at the 5% significance level. Whereas the pH (rs =-0.410) with P-value (0.45) and TDS (rs= -0.564) with P-valve (0.35) had a negative correlation with P-value greater than 0.05, indicating that these relationships are not statistically significant. The relationship between EC and parasite numbers was minimal, with a near-zero correlation (rs=−0.051) and a P-value of 0.95. confirming that there is no significant correlation between the EC and the number of parasites (table II).

Table II: Correlation table between the physicochemical parameters

	Number of parasite	
	r_s	P
T°C	0.900	0.083
pH	-0.410	0.45
Conductividy	-0.051	0.95
TDS	-0.564	0.35

rs= Correlation of Spearman

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DISCUSSION

A total number of 50 soil samples obtained from different stations were examined, and all of them were found to be infected, resulting in a 100% infection rate. The presence of the infective forms of intestinal parasites in soil samples could be due to physiochemical parameters which are favorable to their development and maintenance in the environment. The infection rate observed in this study, is relatively high compared to that reported by Ngatou et al. (2017) in Bazou (Western region of Cameroon) who recorded a prevalence rate of 26%. The difference in these rates may be attributed to environmental factors such as climate, topography, temperature, soil type, rainfall and the use of human faeces as fertilizer for crops.

In this study, protozoa more frequent infestation, representing 76.29% of cases in the analyzed soil samples. This highlights the dominant presence of protozoa in the sampled environment. Similarly, Ajeagah et al. (2019) reported a higher abundance of protozoan cysts (about 14037cysts) in muddy soils compared to groundwater, demonstrating that soils, particularly muddy ones, are more conducive to the persistence and dissemination of cysts. These findings suggested that soils, especially those with high moisture content, provide a favorable environment for protozoan survival and transmission.

Cryptosporidium spp (74 ± 12.16%) was the most common protozoa found in this study in the soil samples. This result is similar to that reported by Tsomene et al. (2020) who reported the highest cyst count of about 2672 oocysts. The high prevalence of *Cryptosporidium* spp. Oocysts can be attributed to their high concentration in faeces, their small size, and their ability to adhere to suspended particles, allowing them to better withstand various environmental stresses. Ashbolt et al. (2004) emphasize that microorganisms generally associated with substrates exhibit strong resistance. *S. stercoralis* was the main parasitic helminth found. This result aligns with that of Fotseu et al. (2021) 74.46%, this high percentage of viability can be explained by the fact that, unlike other helminth species, *S. stercoralis* is present in nature as a larva, this larva can therefore use certain substrates in nature to feed and remain viable. However, in other species, the embryogenesis process stops once the egg is in the wild.

The analysis of parasitic abundance across the five stations (A to E) revealed significant variations, with Station C and D exhibiting the highest parasitic load. These findings suggested a heterogeneous distribution of parasites within the study area, which could be influenced by several ecological factors, including habitat quality, environmental conditions, and host availability. The higher abundance in these Stations may be attributed to favorable conditions that promote the proliferation of parasites, such as higher organic matter or the presence of specific hosts that support parasite life cycles. In contrast, the lower abundance could indicate less conducive environmental conditions or lower host density, leading to reduced parasite survival and reproduction. This pattern aligns with previous studies conducted in Cameroon. For instance, Ntonifor et al. (2015), Ngwa et al. (2020) also documented significant discrepancies in parasitic abundances related to environmental parameters in their study on soil and water parasites in the Littoral region of Cameroon. These results underscore the necessity for continued monitoring and assessment of parasitic dynamics in various habitats, as understanding these patterns can inform management strategies for public health and environmental conservation (Ahmed et al., 2015). Environmental risk factors such as unsafe water, inadequate sanitation and hygiene, and should be assessed.

Regarding the relationship between the physicochemical parameters (T°C, pH, EC and TDS) and the number of parasites, results shown that, excepted Temperature which was positively correlated with the number of parasites, the other physicochemical parameters (pH and TDS) were negatively correlated with the number of parasites and there was no correlation between EC and the number of parasites. The existence of a positive and non-significant correlation of the temperature may be related to the fact that soil temperature plays a critical role in parasite distribution. Optimal temperatures can accelerate larval development, while extreme temperatures may hinder their survival, this indicates that temperature may be a key factor in the distribution and survival of the infective forms of intestinal parasites. These results align with the findings of Nola et al. (2006) conducted in Central Africa who recorded an average temperature of 25.5°C for the de. The negative and non-significant correlation of the pH value with the number of parasites in this study provides a slightly acidic to neutral environment that supports the survival of parasitic eggs, including Hookworms and *Strongyloides* spp. These findings corroborate those of Ajeagah et al. (2010), who noted that near-neutral pH promotes the adhesion and dissemination of parasitic cysts. Additionally, Asi et al. (2021) found that acidic pH reduces oocyst infiltration, supporting the idea that lower pH may act as a barrier, while neutral pH at other promotes infiltration.

Warmer temperatures often accelerate the development rates of parasites and increase vector activity, expanding the geographic range of parasitic diseases. Human activities like deforestation, dam construction, and urbanization disrupt food webs. This can concentrate hosts, altering the probability of parasite-host contact. Contaminants and heavy metals can either suppress the immune systems of hosts (making them more vulnerable) or directly affect the parasites themselves. While viewed mostly as detrimental, parasites are essential components of healthy ecosystems: Because they are highly sensitive, shifts in parasite populations can serve as early-warning bioindicators for environmental degradation and pollution. Parasites regulate the population sizes of their hosts, preventing the overdominance of certain species and maintaining biodiversity.

In natural environments, organisms face anthropogenic stressors such as temperature changes, habitat alterations and pollution. Parasites can also be affected by these pollutants. The interactions between parasites and pollutants are diverse, leading to the development of the field of environmental parasitology over the past 30 years. Today, the field has expanded to investigate a wide range of anthropogenic stressors and their interactions with parasites, including their combined effects on host health. Environmental parasitology also explores the use of parasites as indicators of pollutants and other environmental changes Ntonifor et al. (2015) and Ngwa et al. (2020).

CONCLUSION

This study identified the diversity of the infective forms of intestinal parasites in some waste disposals in the municipality of Yaounde III, and examined how environmental factors influence parasitic distribution. Results of the study revealed a 100 % infection rate in soil samples. Globally, protozoa were more frequent (76.29 %) than helminths (23.71%). At least 20 parasite species were identified in soil samples, and *Cryptosporidium* spp was the most prevalent species (74 ± 12.16%). Among the five sampling sites, station C and D exhibited high parasitic load (with respectively 232.5 and 537.5 parasites). Excepted temperature, no correlation was observed between the physicochemical parameters of the soil and the number of the infective forms of intestinal parasites. Environmental factors, such as slightly acidic to neutral pH and an average temperature of 26.6°C, supported the parasite survival. These findings emphasize the need for improved sanitation and community education to mitigate infection risks and reduce the prevalence of intestinal parasitic infections.

Conflict of interest

The authors declare that there is no conflict of interests.

Authors' contribution

Conception and design of the study: KOGA Mang'Dobara, AJEAGAH GIDEON Aghaindum,; Contribution of material and reagents : AJEAGAH GIDEON Aghaindum; Samples collection, soil and data analysis : MAMBOUNE Sylvie Martine ; Writing the article: KOGA Mang'Dobara; Revising the article critically for important intellectual content Mahob Raymond Joseph and AJEAGAH GIDEON Aghaindum. All the authors read and approved the final version of the manuscript.

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