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Assessment of gastrointestinal parasites in burst sewer effluents in Nsukka zone, Enugu State, Nigeria using various diagnostic methods and community practices

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Abstract

Gastrointestinal parasites threaten public health where sewage is improperly managed. Untreated sewage in the environment increases the risk of disease transmission. This study investigated gastrointestinal parasites in effluents from broken sewers and assessed the Knowledge, Attitudes, and Practices (KAP) of the local population in Nsukka, Enugu State, Nigeria. A total of 463 effluent samples were collected and analysed using zinc sulphate ($ZnSO_4$) flotation and formol-ether concentration techniques. Structured questionnaires were administered to 367 residents to assess KAP regarding gastrointestinal parasites. Overall parasite prevalence was 28.10% and 9.70% using formol-ether and $ZnSO_4$, respectively. With formol-ether technique, prevalence varied considerably across sites ($\chi^2 = 37.54$, p=0.04). Nsukka town had the highest number of species (6). The prevalence of *Strongyloides stercoralis* was highest, especially in Ibagwa-Aka. Helminths (17.50%) were more common than Protozoa (9.30%). The highest parasite occurrence was in June (31.2%) and July (15.90%), and 56.4% of the respondents considered sewage a source of infection. Open defecation (28.60%) and use of untreated water (46.00%) were prevalent risky behaviours. Burst sewers are reservoirs and pathways for the spread of gastrointestinal parasites. Therefore, proper maintenance of sewers and community health education are necessary to prevent public health risk.

Introduction

Sewage system management and treatment are receiving great attention as environmental safety and public health awareness worldwide grow, especially in urban areas, where infrastructure failures can have life-threatening consequences due to a range of barriers (Souza *et al* 2025). Forty per cent (40%) of the world's population lack access to safe sanitation facilities, posing a major health risk (Ritchie *et al* 2024). Burst sewage lines are major sources of environmental contamination because they can release untreated or partially treated human and animal faecal waste containing numerous pathogenic organisms, including Gastrointestinal Parasites (GIP), directly into the environment (Wright 2022). These parasites pose significant health risks to human populations and can persist in the environment for extended periods, making them harmful contaminants.

Gastrointestinal parasites are broadly classified into two major groups: protozoa and helminths. Protozoan parasites, such as *Giardia lamblia*, *Entamoeba histolytica*, and *Cryptosporidium* spp., are unicellular organisms that cause severe diarrheal diseases (Hemphill *et al* 2019). Helminth parasites such as *Ascaris lumbricoides* (Roundworm), *Trichuris trichiura* (Whipworm), Hookworms (*Ancylostoma* duodenale and *Necator americanus*), *Strongyloides stercoralis* (Threadworm), *Taenia* spp, *T. solium* (Pork tapeworm), *T. saginata* (Beef tapeworm), *Hymenolepisnana* (Dwarf tapeworm), *Diphyllobothrium latum* (Fish tapeworm), *Fasciolopsis buski* (The giant intestinal fluke), and *Echinostoma* spp. are multicellular parasites that cause a range of gastrointestinal disturbances and malnutrition (Toledo *et al* 2024). Gastrointestinal parasites are often transmitted through the ingestion of contaminated food or water or through direct contact with contaminated soil (Yahia *et al* 2023).

Gastrointestinal parasitic infections remain a significant public health concern globally, particularly in regions with underdeveloped or compromised sanitation systems (Yimam *et al* 2020; Dhakal *et al* 2024; Wondmagegn *et al* 2025). These infections, caused by helminths and protozoans invade the gastrointestinal tract and are a major contributor to health issues, including malnutrition, diarrhoea, and even death, especially among vulnerable populations such as children, the elderly, and individuals with compromised immune systems and in severe cases, chronic infections can result in anaemia (especially with hookworm infections), stunted growth in children, and impaired cognitive development (Hotez *et al* 2008; WHO 2025).

The World Health Organisation estimated that more than 1.5 billion people worldwide are infected with soil-transmitted helminths, while waterborne protozoan infections such as *Giardia intestinalis* and *Entamoeba histolytica* continue to cause significant morbidity in low- and middle-income countries (WHO 2023; Frontiers in Epidemiology 2025). Wastewater and sewage effluents are recognised reservoirs for these pathogens, often acting as transmission routes when discharged untreated into the environment (Benito *et al* 2020). Studies in Europe and Latin America have detected diverse parasitic cysts and ova in effluents and sludge, indicating that even conventional treatment systems may not eliminate infectious forms (Sabbahi *et al* 2018).

In many developing countries, especially across sub-Saharan Africa, sewage disposal systems are poorly maintained, leading to accidental sewage line bursts that directly contaminate the environment. Several studies have consistently reported high prevalence rates of GI parasitic infections in Nigeria, particularly in areas with poor sanitation and inadequate waste management (Jombo *et al* 2007; Okojokwu *et al* 2014; Karshima 2018; Funso-Aina *et al* 2020). Previous research in urban centres such as Jos revealed a high prevalence of intestinal parasites in abattoir effluents, demonstrating the public health risks posed by untreated wastewater (Daminabo and Damen 2020).

In Nsukka, Enugu State, poorly maintained sewage systems and burst lines are common, especially in areas with ageing infrastructure (Street Reporters 2024; Ugwu 2024). Despite the obvious environmental risks, limited research has assessed the parasitological content of sewage effluents in this region. Therefore, this study aims to evaluate the prevalence and distribution of gastrointestinal parasites in effluents from burst sewage lines using different diagnostic methods, compare the efficacy of these methods, and assess residents' Knowledge, Attitude and Practices (KAP) regarding sewage-related health risks in Nsukka Zone, Enugu State, Nigeria.

Materials and methods

Study area and design

The study adopted a cross-sectional descriptive design and was conducted over four months, from April to July 2025, in Nsukka Zone, Enugu State, Nigeria. Nsukka Zone has a total land area of about 45.38km^2 and an elevation of 1,810ft (552m), with a population of 309,633 (NPC 2009). The study area was stratified into three Local Government Areas (LGAs): Nsukka, Udenu, and Igbo-Eze South, to ensure adequate geographical representation. Participants were selected using the cardinal sampling method, while the ballot method (simple random sampling) was employed to select the study communities. Nsukka, as a geopolitical zone, is bounded by Latitudes 6°49'N and 6°52'N and Longitudes 7°21'E and 7°24'E. In Nsukka LGA, the sampled communities include Nsukka town, Onuiyi, Obukpa, Ede-Oballa, and Opi. In Udenu LGA, the sampled communities include Orba and Imilike, while in Igbo-Eze South LGA, the communities were Ibagwa-Aka and Iheakpu-Awka. Two seasons are observed in the study area: the wet season, from April to October, and the dry season, from November to March.

Sample size

The sample size was determined using Cochran's formula for calculating a minimum sample size (Cochran, 1997), which provided the required sample size.

$$N = \frac{Z^2\,(p)(1-p)}{d^2}$$

Where: N = required sample size, Z = Z-value (Z-score), which corresponds to the desired confidence level (1.96 for 95% confidence level), p = estimated prevalence (p = 0.50), and d = margin of error (precision), fixed at 0.05.

The estimated sample size was 384. However, a total of 463 effluent samples were collected and analysed. The increase was intended to ensure adequate representation across the study area.

Sample collection

Effluent samples were collected once a month into clean, wide-mouthed, leak-proof universal containers using clean scoops. Each sample bottle was properly labelled with the location name for clear identification. Effluent samples were transported to the Department of Zoology and Environmental Biology Postgraduate Laboratory at the University of Nigeria, Nsukka, for laboratory analysis.

Questionnaire administration

A well-structured questionnaire was carefully designed and used to collect demographic information, knowledge of sewage and parasites, attitudes towards sewage and health risks, practices related to sewage, hygiene and experience with burst sewer. A total of 367 questionnaires were administered to the respondents for data collection.

Parasitological examination

Two standard parasitological examinations were performed to detect gastrointestinal parasites: the Formol-ether concentration and Zinc sulphate flotation techniques (Ayres *et al* 1997; Al-Nihmi *et al* 2020). Microscopic examination was done at ×10 and ×40 magnifications using Optika B-31 binocular microscope.

Data analysis

Data were analysed using IBM SPSS software, version 25.0 (IBM Corporation, Armonk, USA). Descriptive statistics (frequencies and percentages) were used to determine the overall, locational, and monthly prevalence of gastrointestinal parasites and also to summarise data from the Knowledge, Attitudes, and Practices (KAP) questionnaire. The Chi-square (χ^2) test was used to assess variations in parasite prevalence across the study locations and sampling months. The nonparametric Kruskal–Wallis test was used to analyse variation in parasite load (mean intensity) across locations and months, and the Mann–Whitney U test was used to compare the overall mean parasite load between the two diagnostic techniques.

Results

Overall prevalence of gastrointestinal parasites

Of the 463 sewage samples examined, 9.70% (45/463) gastrointestinal parasites were detected by the flotation method, and 28.10% (130/463) by the formol-ether concentration method. There were no significant (p>0.05) differences in the prevalence of parasites between flotation and formol-ether diagnostic techniques (Table 1).

Spatial distribution of parasites

The prevalence of parasites varied across the nine communities sampled. The highest prevalence of parasites, using both methods, was at Imilike (15.60% and 34.40% for the flotation and formol-ether methods, respectively). The highest number of parasite species was recorded in Nsukka town, where six (6) species were detected (Table 1).

Prevalence of the protozoan and helminth parasites

Table 2 shows the overall prevalence of protozoan and helminth parasites across the study sites, using the flotation and formol-ether techniques. The prevalence of protozoa was generally 4.00% or less, except at Obukpa (6.30%), Opi (5.10%), and Imilike (12.70%); and overall protozoa prevalence by the flotation technique was 3.70%. Using the flotation technique, at least one sample had helminth infection in all nine locations, except at Ede-Oballa with 0.00% prevalence. However, the highest helminth prevalence was 11.1% (Iheakpu), followed by Nsukka (5.80%); and overall was 5.80%. Mixed protozoa-helminth infection from the flotation technique was 0.0% in all locations. The difference between protozoa and helminth prevalence by sampled locations from the flotation technique was not significant (χ^2=30.18, df =24, p=0.18).

The formol-ether techniques were more sensitive than the flotation techniques as overall prevalence of protozoa (9.30% vs. 3.70%), helminths (17.50% vs. 5.80%), and mixed infection (1.30% vs. 0.00%) were higher in formol-ether than flotation technique. Protozoa prevalence from the formol-ether technique was highest in Imilike (28.10%), followed by Iheakpu (13.90%) and Obukpa (12.50%), and least in Opi (0.00%). Helminth infection by formol-ether was highest in Onuiyi (26.20%) and Nsukka (22.60%). The difference in prevalence by location from the formol-ether concentration technique was significant (χ^2=37.54, df=24, p=0.04).

Mean distribution of the parasites according to diagnostic techniques

The distribution of gastrointestinal parasites by diagnostic technique is presented in Table 3. The mean density in cysts per gram of faeces for protozoa in the nine locations sampled was 1.58±0.58 cpg (at Nsukka and Imilike) or less from the flotation technique. However, the differences were not significant (p>0.05). Protozoan mean densities from the formol-ether technique were generally higher compared to the flotation technique, except at Opi. Similar to the flotation technique, Nsukka (3.75±1.11 cpg) and Imilike (2.50±0.50 cpg) also had the two highest protozoa densities. The difference in protozoan densities by sample locations was significant (Kruskal-Wallis U-statistics = 16.70, p=0.03). The intensity of helminth egg isolates was highest at Nsukka (2.00±0.41 epg), followed by Iheakpu (1.25±0.63 epg), and least at Ede-Oballa and Imilike (0.25±0.25 epg); however, the differences were not significant (p>0.05). The intensity of helminth eggs by the formol-ether technique was generally higher compared to flotation. Helminth intensity by the formol-ether technique was highest in Nsukka and least in Imilike, and the difference was significant **(**p<0.05**)** compared to the other locations.

Table 1: Prevalence of gastrointestinal parasites in the study area using flotation and formol-ether concentration techniques

Location	No. of samples examined	Number infected		Prevalence (%)	
		Floatation Technique	Formol-ether Technique	Floatation Technique	Formol-ether Technique
Nsukka town	137	12	46	8.8	33.6
Onuiyi	42	3	14	7.1	33.3
Obukpa	48	6	13	12.5	27.1
Ede-Oballa	29	2	6	6.9	20.7
Opi	39	5	7	12.8	17.9
Iheakpu	36	5	10	13.9	27.8
Ibagwa-Aka	48	4	13	8.3	27.1
Orba	52	3	10	5.8	19.2
Imilike	32	5	11	15.6	34.4
Total	**463**	**45**	**130**	**9.7**	**28.1**

*Differences in prevalence among locations were not statistically significant (Chi-square test, p > 0.05)

**Flotation: χ^2 = 8.08, *df* = 8, p = 0.43; Formol-ether: χ^2 = 8.08, *df* = 8, p = 0.43

Monthly prevalence of gastrointestinal parasites

Using the flotation method, a significant variation in prevalence was observed across the months (χ^2=7.81, df=3, p=0.05), with the highest number of parasites recorded in July (15.90%). In contrast, the parasites detected using the formol-ether concentration method did not show a significant difference in prevalence across the months (p>0.05) (Figure 1).

Table 2: Prevalence of protozoan and helminth parasites in the study area

Technique	Location	Protozoa (%)	Helminths (%)	Mixed Infection (%)	Uninfected (%)
Flotation	Nsukka town	4 (2.9)	8 (5.8)	0 (0.0)	125 (91.2)
	Onuiyi	1 (2.4)	2 (4.8)	0 (0.0)	39 (92.9)
	Obukpa	3 (6.3)	3 (6.3)	0 (0.0)	42 (87.5)
	Ede-Oballa	1 (3.4)	0 (0.0)	0 (0.0)	27 (93.1)
	Opi	2 (5.1)	3 (7.7)	0 (0.0)	34 (87.2)
	Iheakpu	1 (2.8)	4 (11.1)	0 (0.0)	31 (86.1)
	Ibagwa-Aka	1 (2.1)	3 (6.3)	0 (0.0)	44 (91.7)
	Orba	0 (0.0)	3 (5.8)	0 (0.0)	49 (94.2)
	Imilike	4 (12.5)	1 (3.1)	0 (0.0)	27 (84.4)
	Total	**17 (3.7)**	**27 (5.8)**	**0 (0.0)**	**419 (90.5)**
Formol-ether	Nsukka town	12 (8.8)	31 (22.6)	3 (2.2)	91 (66.4)
	Onuiyi	2 (4.8)	11 (26.2)	1 (2.4)	28 (66.7)
	Obukpa	6 (12.5)	7 (14.6)	0 (0.0)	35 (72.9)
	Ede-Oballa	3 (10.3)	3 (10.3)	0 (0.0)	23 (79.3)
	Opi	0 (0.0)	7 (17.9)	0 (0.0)	32 (82.1)
	Iheakpu	5 (13.9)	5 (13.9)	0 (0.0)	26 (72.2)
	Ibagwa-Aka	5 (10.4)	8 (16.7)	0 (0.0)	35 (72.9)
	Orba	1 (1.9)	8 (15.4)	1 (1.9)	42 (80.8)
	Imilike	9 (28.1)	1 (3.1)	1 (3.1)	21 (65.6)
	Total	**43 (9.3)**	**81 (17.5)**	**6 (1.3)**	**333 (71.9)**

*Probability values are considered significant at **$p<0.05$** using the **Chi-square test**.
**Flotation: $\chi^2 = 30.18$, $df = 24$, $p = 0.18$; Formol-ether: $\chi^2 = 37.54$, $df = 24$, $p = 0.04$

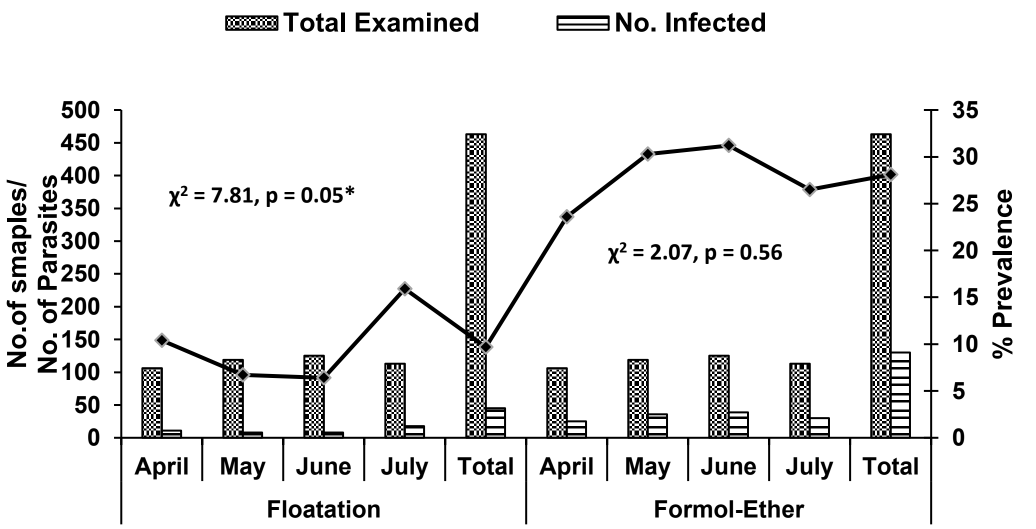

Figure 1: Monthly prevalence of gastrointestinal parasites in the study area

Intensity of gastrointestinal parasites in the study area
Table 4 shows the mean parasite intensity at different locations in the study area. The parasites recovered were *Entamoeba histolytica*, *Ascaris lumbricoides, Ancylostoma duodenale, Enterobius vermicularis, Strongyloides stercoralis* and *Taenia* spp., but species composition differed by sampled locations. At Nsukka, five parasite species were isolated with the mean intensity of each below 3.00 epg or cpg. The mean intensities of the parasite isolates were generally between 1.00 and 2.00 epg, except for *Taenia* spp. at Nsukka (2.80±0.73 epg) and *Strongyloides stercoralis* at Ibagwa-Aka (3.14±0.83 epg) and obukpa (2.29±0.52 epg). There was no significant difference ($p>0.05$) in the mean intensity of detected parasites across all studied locations.

Knowledge of sewage and gastrointestinal parasites among respondents
Of the 367 respondents**,** 61.60% (n=226) had heard of gastrointestinal parasites, while 56.4% (n=207) were aware that sewage effluents can carry such parasites (Table 5). Almost all respondents recognised the risk associated with consuming contaminated water **(**99.50%**)** and unwashed vegetables (100%).

Table 3: The mean distribution of parasites according to diagnostic technique

Location	Protozoans		Helminthes	
	Flotation Mean ± SE (cpg)	Formol-ether Mean ± SE (cpg)	Flotation Mean ± SE (epg)	Formol-ether Mean ± SE (epg)
Nsukka	1.00 ± 0.58	3.75 ± 1.11[b]	2.00 ± 0.41	9.75 ± 2.32[c]
Onuiyi	0.25 ± 0.25	0.75 ± 0.48[a]	0.50 ± 0.29	3.75 ± 0.95[b]
Obukpa	0.75 ± 0.48	1.50 ± 0.65[b]	0.75 ± 0.25	1.75 ± 0.75[b]
Ede-Oballa	0.50 ± 0.29	0.75 ± 0.25[a]	0.25 ± 0.25	0.75 ± 0.25[a]
Opi	0.50 ± 0.29	0.00 ± 0.00[a]	0.75 ± 0.25	1.75 ± 0.48[b]
Iheakpu	0.25 ± 0.25	1.25 ± 0.63[b]	1.25 ± 0.63	1.25 ± 0.25[b]
Ibagwa-Aka	0.25 ± 0.25	1.25 ± 0.75[b]	1.00 ± 0.41	2.50 ± 0.87[b]
Orba	0.00 ± 0.00	0.50 ± 0.29[a]	0.75 ± 0.25	2.25 ± 0.75[b]
Imilike	1.00 ± 0.58	2.50 ± 0.50[b]	0.25 ± 0.25	0.50 ± 0.28[a]
	U statistics = 5.70, p=0.68	U statistics = 16.70, p=0.03	U statistics = 13.303, p=0.10	U statistics = 19.77, p=0.01

*U-statistics from the Kruskal-Wallis test. **Different superscripts indicate significant differences using Dunn's post-hoc test ($p < 0.05$). ***epg – egg per gram of faeces. cpg – cyst per gram of faeces.

Table 4: The mean intensity of parasites detected in the study area

Location	Recovered parasites	Mean ± SE (epg or cpg faeces)	K	p-value
Nsukka	*Entamoeba histolytica*	1.37 ± 0.11	9.757	0.082
	Ascaris lumbricoides	1.33 ± 0.17		
	Ancylostoma duodenale	1.20 ± 0.20		
	Enterobius vermicularis	1.00 ± 0.00		
	Strongyloides stercoralis	1.71 ± 0.21		
	Taenia spp.	2.80 ± 0.73		
Onuiyi	*Entamoeba histolytica*	1.33 ± 0.33	0.268	0.966
	Ascaris lumbricoides	1.33 ± 0.33		
	Ancylostoma duodenale	1.60 ± 0.60		
	Strongyloides stercoralis	1.89 ± 0.51		
Obukpa	*Entamoeba histolytica*	1.56 ± 0.29	2.652	0.449
	Ascaris lumbricoides	1.00 ± 0.00		
	Ancylostoma duodenale	1.00 ± 0.00		
	Strongyloides stercoralis	2.29 ± 0.52		
Ede-Oballa	*Entamoeba histolytica*	1.20 ± 0.20	0.800	0.849
	Ancylostoma duodenale	1.00 ± 0.00		
	Strongyloides stercoralis	1.00 ± 0.00		
	Taenia spp	1.00 ± 0.00		
Opi	*Entamoeba histolytica*	1.50 ± 0.50	0.317	0.853
	Ancylostoma duodenale	1.25 ± 0.25		
	Strongyloides stercoralis	1.50 ± 0.34		
Iheakpu	*Entamoeba histolytica*	1.17 ± 0.17	2.083	0.555
	Ascaris lumbricoides	1.25 ± 0.25		
	Ancylostoma duodenale	1.00 ± 0.00		
	Strongyloides stercoralis	1.50 ± 0.29		
Ibagwa-Aka	*Entamoeba histolytica*	1.60 ± 0.24	7.621	0.106
	Ascaris lumbricoides	1.50 ± 0.50		
	Ancylostoma duodenale	1.00 ± 0.00		
	Strongyloides stercoralis	3.14 ± 0.83		
	Taenia spp	2.00 ± 0.00		
Orba	*Entamoeba histolytica*	1.00 ± 0.00	2.828	0.243
	Ancylostoma duodenale	1.00 ± 0.00		
	Strongyloides stercoralis	1.56 ± 0.24		
Imilike	*Entamoeba histolytica*	1.50 ± 0.26	1.250	0.535
	Ascaris lumbricoides	1.00 ± 0.00		
	Ancylostoma duodenale	1.00 ± 0.00		

*epg: eggs per gram faeces for helminths; cpg: cysts per gram faeces for protozoans. **All values are expressed as mean ± standard error (±SE). ***Probability values are significant at $p < 0.05$ using the Kruskal-Wallis test.

Table 5: Knowledge of respondents about sewage and gastrointestinal parasites (n = 367)

Variable	Response	n (%)
Have you ever heard of gastrointestinal parasites?	Yes	226 (61.6)
	No	141 (38.4)
Do you know that sewage effluents can carry gastrointestinal parasites?	Yes	207 (56.4)
	No	160 (43.6)
Common symptoms of gastrointestinal parasite infection*	Stomach pain	218 (59.6)
	Diarrhea	229 (62.6)
	Vomiting	67 (18.3)
	Weight loss	139 (38.0)
	Fever	55 (15.0)
	None of the above	102 (27.9)
Parasites that may be found in sewage effluents*	Protozoan	77 (13.4)
	Roundworm	175 (30.4)
	Tapeworm	136 (23.6)
	No idea	188 (32.6)
Drinking water from sources near burst sewage lines can lead to parasitic infection	Yes	365 (99.5)
	No	0 (0.0)
	Do not know	2 (0.5)
Eating unwashed vegetables/fruits near sewage lines can cause infection	Yes	367 (100)
	No	0 (0.0)
	Do not know	0 (0.0)
Using wastewater to irrigate crops increases risk of gastrointestinal parasite transmission	Yes	278 (75.7)
	No	63 (17.2)
	Not sure	26 (7.1)

*Multiple responses allowed.

Hygiene practices and exposure to burst sewage

About 46.00% reported using untreated water directly from the source, 105 (28.60%) households practised open defecation, while 51.80% consistently used soap for handwashing, and 50.40% dewormed only when sick (Table 6).

Discussion

The findings demonstrate significant environmental contamination with enteric parasites, highlighting poor sanitation infrastructure as a key contributor to ongoing public health risks in the region. Inadequate sanitation infrastructure, such as damaged sewage systems, poor waste management, and lack of latrines, has been universally recognised as a veritable factor in disease spread, particularly in developing countries. **(**Prüss-Ustün *et al* 2014, WHO 2019).

The superior diagnostic sensitivity of the formol-ether technique over the flotation technique was demonstrated by detecting 28.10% and 9.70% of overall GI parasites, respectively. This confirms the superior diagnostic sensitivity of sedimentation techniques for parasite recovery, particularly for heavy helminth eggs, as previously documented by Ayres *et al* (1991), Cheesbrough (2009), Wajahat *et al* (2016), and Benito *et al* (2020). Maqsood *et al* (2018) reported that the flotation fluid caused the collapse of the walls of cysts and eggs, thereby hindering the detection and identification of parasites. In contrast, sedimentation techniques preserve their integrity, thereby improving diagnostic accuracy and reducing misidentification (Wajahat *et al* 2016). They also highlighted the lower specific gravity of the sedimentation solution as an advantage over flotation. Contrary to this report, the sedimentation technique is not universally superior for all parasites. Katagiri and Oliveira-Sequeira (2010) reported that the flotation technique was more accurate than other techniques for many helminth parasites they studied. Maqsood *et al* (2018) compared the efficacy of the gauze filtration technique with that of the conventional wet preparation and sedimentation methods. They detected more parasites using the gauze filtration method than the sedimentation method and reported the sensitivity and specificity of the gauze filtration technique to vary between 95.80% and 100%.

In the present study, spatial variation was evident, as the highest prevalence was recorded at Imilike and Nsukka. This agrees with Lima *et al* (2023), who observed significant spatial heterogeneity in parasitic contamination associated with local sanitation quality. Frequent sewer bursts, high population density, and ageing pipelines in urban centres such as Nsukka are likely to exacerbate the release of untreated effluents. Comparable patterns have been reported in other urban studies in Nigeria (Okafor *et al* 2021) and South Asia (Tariq and Mushtaq 2023).

Table 6: Hygiene practices, environmental exposure, and burst sewage experience (n = 367)

Variable	Response	n (%)
Seek medical treatment when gastrointestinal infection is suspected	Yes	217 (59.1)
	No	61 (16.6)
	Sometimes	89 (24.3)
Primary household toilet facility	Pit latrine	76 (20.7)
	Flush toilet	233 (63.5)
	Bucket toilet	18 (4.9)
	Composting toilet	1 (0.3)
	None (open defecation)	39 (10.6)
Toilet facility shared with other households	Yes	66 (18.0)
	No	270 (73.6)
Household practices open defecation	Yes	105 (28.6)
	No	161 (43.9)
	Only during toilet maintenance	100 (27.2)
Reasons for open defecation*	Lack of toilet facility	56 (26.8)
	Toilet unusable/damaged	88 (42.1)
	Cultural preference	1 (0.5)
	Other	64 (30.6)
Household experienced burst sewage line	Yes	224 (61.0)
	No	39 (10.6)
	Not applicable	104 (28.3)
Frequency of burst sewage occurrence	Frequently	8 (2.2)
	Rarely	116 (31.6)
	Occasionally	96 (26.2)
	Not applicable	147 (40.1)
Time taken to repair burst sewage	< 1 day	42 (11.4)
	1–3 days	69 (18.8)
	> 3 days	99 (27.0)
	Never fixed	10 (2.7)
	Not applicable	147 (40.1)
Have you ever taken any personal action to manage a burst sewage problem in your household (e.g. temporary covering, cleaning or rerouting)	Yes	98 (26.7)
	No	59 (16.1)
	Sometimes	63 (17.2)
	N/A	147 (40.1)
How often do you come into direct contact with sewage effluent in your area?	Frequently	84 (22.9)
	Occasionally	210 (57.2)
	Never	73 (19.9)
Have you ever taken preventive measures (e.g. handwashing with soap after using toilet) to protect yourself against infection	Yes	190 (51.8)
	No	90 (24.5)
	Sometimes	87 (23.7)
How do you usually handle water for domestic use (drinking, bathing, cooking, etc.)	Boil before use	129 (35.1)
	Filter water	69 (18.8)
	Use directly from the source	169 (46.0)
How often do you wash your raw fruit before eating them?	Always	207 (56.4)
	Sometimes	110 (30.0)
	Rarely	38 (10.4)
	Never	12 (3.3)
How often do you wash your raw vegetables before cooking or eating?	Always	367 (100)
	Sometimes	0 (0)
	Rarely	0 (0)
	Never	0 (0)
How often do you take preventive curative medicine for intestinal parasites (worm and other parasites)	Regularly (at least every 6 – 12 months)	34 (9.3)
	Occasionally (less than once a year)	128 (34.9)
	Only when sick	185 (50.4)
	Never	20 (5.4)

*Multiple responses allowed

Helminths predominated over protozoa (17.5% vs 9.3%), reflecting their environmental resilience and thick protective shells, which enable prolonged survival outside hosts (Mahapatra *et al* 2022). The dominant species, *Strongyloides stercoralis*, *Ancylostoma duodenale*, *Ascaris lumbricoides*, and *Entamoeba histolytica*, are well-recognised indicators of faecal contamination and poor sanitation (Ziegelbauer *et al* 2012; WHO 2023). Similar parasitic assemblages have been documented in effluents and sludge from Tunisia (Sabbahi *et al* 2018), Jos (Daminabo and Damen 2020), and Port Harcourt (Gboeloh 2021). The absence of *Giardia* and *Cryptosporidium* in the present study contrasts with the findings of Lima *et al* (2023). It may reflect diagnostic limitations rather than true absence, underscoring the need for molecular confirmation in future surveillance.

Temporal analysis revealed significantly high prevalence during the rainy month of July (p=0.05), consistent with the role of storm runoff and sewer overflow in dispersing pathogens (Singh *et al* 2022; Suchowska-Kisielewicz and Nowogoński 2021). Amahmid *et al* (2023) similarly linked rainfall peaks to elevated parasite counts in wastewater-irrigated environments. The persistently high mean intensity of *S. stercoralis* observed across several locations in the present study reflects a substantial burden of infection within the source population, as noted by Barzinji (2023) in Iraq. The number of parasite species was highest in Nsukka town, reaffirming the influence of urban density and complex sewage networks on parasite diversity (Gundogdu *et al* 2023).

Some of the detected protozoan (*Entamoeba histolytica*) and helminthes (*Ascaris Lumbricoides, Ancylostoma duodenale, Strongyloides stercoralis, Taenia* spp., and *Enterobius vermicularis*) parasites are of serious public health concern. *Entamoeba histolytica*, which has been associated with sewage effluents and contaminated water, causes amoebiasis and has been widely reported to cause severe morbidity and mortality, ranking next to malaria (Tengku and Norhayati 2011). It is commonly asymptomatic, which makes its pathogenicity more deadly, as the victims are rarely aware of the infection until it has inflicted harm on them, especially peritonitis (Chou and Austin, 2023; Kantor *et al* 2018).

The helminthes, on the other hand, are seriously associated with malnutrition, anaemia, impaired physical and cognitive development, diarrhoea, and peritonitis (in severe cases) (Echazú *et al* 2015). The helminthes are among the neglected tropical diseases. They are often referred to as diseases of poverty because they predominantly affect the poor, who are commonly associated with a lack of sanitation, safe water, and adequate hygiene (Chen *et al* 2024; WHO 2021, 2026).

The KAP assessment revealed that, despite relatively high levels of formal education among respondents, substantial knowledge and behaviour gaps persist. Notwithstanding the respondents' moderate level of awareness (61.6%) of GI parasites, their knowledge of sewage as a transmission route (56.4%) was limited, and their use of untreated water (46%) did not align with their awareness. Similar discrepancies between awareness and safe practice have been described by Eyayu *et al* (2021) and Gadekar (2023). Misconceptions, such as the belief that visually clean vegetables are safe, mirror the risk perceptions reported by Amahmid *et al* (2023). Also, open defecation (28.6%), inconsistent handwashing (51.8%), and reactive deworming (50.4% only when ill) observed in this study are indicators of water, sanitation, and hygiene inadequacies, just as noted by Njambi *et al* (2020) in Kenya.

Collectively, these findings indicate that burst sewage lines in Nsukka constitute a major reservoir and transmission route for enteric parasites. Poor infrastructure, inadequate effluent management, and behavioural risk factors increase the likelihood of reinfection cycles within the community. Addressing this problem requires a combination of infrastructural repair, effluent monitoring, and sustained context-specific public health education. These recommendations are consistent with those of Ngwamah *et al* (2024) and Okojokwu *et al* (2014).

Conclusion

This study investigated the presence of diverse gastrointestinal parasites in effluents from burst sewage lines within the Nsukka Zone using different diagnostic techniques. The findings underscore significant environmental contamination that poses serious threats to public health. Helminthes were more prevalent than protozoans. *Strongyloides stercoralis* had the highest mean intensity across locations, and Nsukka town had the highest number of species. The formol-ether concentration technique proved more efficient in parasite detection than zinc sulphate floatation, indicating its suitability for routine surveillance.

Although the majority of residents were aware of parasitic infections, behavioural practices such as the use of untreated water, irregular handwashing, and open defecation indicate a persistent gap between knowledge and safe hygiene practices. These findings highlight the need for improved sewage management and behavioural risk-reduction strategies to limit continuous environmental contamination and infection transmission within the region. Consistent hygiene education, proper and prompt sewage management, and free access to safe drinking water will help limit the spread of parasitic infections. A cordon sanitaire around wastewater disposal channels will reduce exposure to infection and prevent the spread of parasitic diseases.

Conflict of Interest

The authors declare that there is no competing interest.

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