Vol. 15(1), pp. 10-21, January-March 2023
DOI: 10.5897/JPHE2022.1393
Article Number: 270E44B70190
ISSN 2141-2316

http://www.academicjournals.org/JPHE

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Journal of Public Health and Epidemiology

Full Length Research Paper

Health implications of patronage of open markets: A survey of Shasha market, Oba-ile, Akure, Ondo State, Nigeria

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Received 16 March, 2022; Accepted 26 May, 2022

Most often, patronage of open markets attracts huge populations of buyers in Nigeria. These markets are numerous in each state of the country but largely share similar characteristics in poor hygiene and sanitation. Health Impact Assessment (HIA) was conducted at Shasha market, Oba-Ile, Akure to assess the health implication of patronage of open markets, an emerging public health concern. Air, water and selected food samples were taken for microbial analysis while soil samples from different spots in the market, and faecal samples from residents of the market community were also taken for parasitology. The respective tests followed standard procedures to determine the coliform count and parasitic fauna in the collected samples. Out of 73 faecal samples that were examined, 69 (94.52%) were positive. Hookworm ova had the highest occurrence (40%) followed by *Strongyloides. stercoralis* and *Ascaris lumbricoides* ova which were 33 and 27% respectively. The result also revealed that 95.83% of the collected soil samples were contaminated with helminth eggs and larvae including *Ascaris lumbricoides, Strongyloides stercoralis* and Hookworm. Bacteria and fungi species found in the air, water and food samples include *Staphylococcus aureus, Entamoeba. coli, Klebsiella pneumonia, Salmonella typhi, Rhizopus stolonifer, Penicillium digitatum* and *Aspergillus niger.* The market environment was highly contaminated with various stages of pathogenic organisms of public health importance and this predisposes the buyers and sellers to different communicable diseases. The market requires urgent attention by the concerned government authority in its management and sanitation.

Key words: Health impact assessment, open market, patronage, pathogens.

INTRODUCTION

The popular market system in Nigeria is the open market option where sellers and buyers haggle over prices of goods and services. Most of these open markets do not have stalls (and if they do, very few) as majority of market transactions take place on the bare grounds of the market. It is commonplace in such markets to see fruits,

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vegetables etc. displayed on the ground for sale. Though these markets play a vital role in the economic life of the people, and they are essential in the chain of commodity distribution (World Bank, 2009), community health issues can affect business performance and reputation in markets. For instance, certain diseases, such as malaria and acute respiratory infections, have the potential to cause changes in local workforce productivity, adversely affecting the business (Frankish et al., 1996) and individual health. The presence of communicable diseases can also increase the health care costs of local employees and their families, also a rise in the prevalence of non-communicable diseases such as diabetes, hypertension, cardiovascular, and stress-related diseases can have significant productivity and financial repercussions (Frankish et al., 1996; Adeleye and Olayiwola, 2006). The aetiology of communicable diseases is diverse but in population clusters, parasites and micro-organisms are most often incriminated as foods and goods purchased from open markets can be easily contaminated. Bio aerosols consists of single spores, pollen, bacterial cells and viruses, aggregates of spores, cells, and other biological material, products or fragments of mycelium, fungal spores and bacterial cells, biological material lifted from the ground on its own accord or carried by bigger non-biological particles (Ogorek et al., 2014). The related health effects from these contaminations are an emerging public health problem (Kulkarni et al., 2011). As such, there is a need for various systems to minimize the introduction, generation and retention of particles in the environments (CDC, 2003). Sometimes, however, even very low concentrations of particular microorganisms can cause serious diseases (Stryjkowska et al., 2007). Health Impact Assessment (HIA) is a tool that helps decision-makers identify the public-health consequences of proposals that potentially affect health (WHO, 1999). Where people live, work, and play can directly and indirectly influence behaviours, individual health, and collectively, community health (Lock, 2000). HIA also tries to identify benefits to health that may be enhanced (De Jesus, 2009; IAIA, 2014). Shasha market located in Akure, the state capital of Ondo state, Nigeria, is the major pepper and tomato market in the megacity. It receives a huge traffic on daily basis in buyers and sellers. Apart from pepper and tomato, other kinds of foods are also sold. There are some traders who have stalls where they retail their goods but the tomato and pepper transactions are always on the bare ground, as well as other fruits and vegetables. Because of open nature and poor sanitation of the market site for this survey, various practices which were seen as normal, may rather predispose the visitors and residents to high risk of contracting infections. Thus, it is imperative to carry out the Health Impact Assessment of the market to gather baseline information, and use it as a tool to influence decision of the policy makers. Only a few assessments have been completed following the various stages involved in HIA (McCormick and Blau, 2008), using the several approaches (Joffe and Mindell, 2005), the current study is one of such.

MATERIALS AND METHODS

Study site

The study site was Shasha market (5°14´35´´E, 7°16´40´´N), a major organic farm produce daily market situated along Akure-Owo Expressway, about a kilometre away from Oba-Ile township in Akure North Local Government Area of Ondo State, Nigeria (Figure 1).

Ethical considerations

Advocacy visits were paid to the Market Community Leader and the Coordinator of Primary Health Care facility in the market. Following these approvals, informed consent was obtained from voluntary participants who visited the health centre. All participants allowed were adults as no minor was recruited into the study. No invasive procedure was employed in the collection of all samples. Site assistants were employed at the market to fast-track good relationship and communication amidst the Hausa tribe that make up the bulk of the population.

Sample collection

The study design was randomized. Air samples were taken randomly via natural sedimentation method at open spaces in the market using Agar plates of different media (nutrient agar (NA), MacConkey agar, Deoxycholate Citrate Agar, Malt Extract agar, Mannitol Salt agar) placed at the entrance, centre and at the back of the market in the morning, afternoon and evening. Well water samples were collected aseptically using sterile 200ml screwed capped glass bottles following standard protocol (APHA, 1992), Physico-chemical parameters of six well water samples were determined using H19813-6 multi-meter (Hanna, USA) for pH, total dissolved solid, electrical conductivity and temperature while a portable dissolved oxygen meter (H196732, Jenway, United Kingdom) was used to determine dissolved oxygen. The collected samples were carefully capped, placed on ice and transported to the laboratory for microbiological analysis and the results compared with WHO standard for drinking water. The index of microbial air contamination of the markets was measured thrice a week as described by Pasquarella et al. (2000). Approximately 100g of soil was collected at a depth of 2–3 cm, 50 m apart to a distance of 300 metres along the four cardinal points from the epicentre of the market square and repeated at the market dumpsite (Hassan et al., 2017; Hassan and Oyebamiji, 2018), the Geographical Coordinates (Table 1) of the sites was recorded accordingly using a global positioning system (GPS) device (eTrex©, Garmin International Inc., Olathe, US). Samples from different points within the sampling site were transported using properly labelled polythene bags until laboratory analysis. The collections were done from 06:00 hrs to 10:00hrs, when the larvae and eggs of geohelminths were expected to be active (Nwoke et al., 2013). Faecal samples were collected in plastic screw cap bottles. Samples were collected by health officers from patients who visited the health centre. The samples were transported to the laboratory and kept in the refrigerator at 4^0C until analysed. Samples of cooked rice and beans were randomly obtained from food sellers and canteens in the market. Samples were collected in sterile containers, and taken under aseptic condition to the laboratory for microbiological analysis. Vegetables

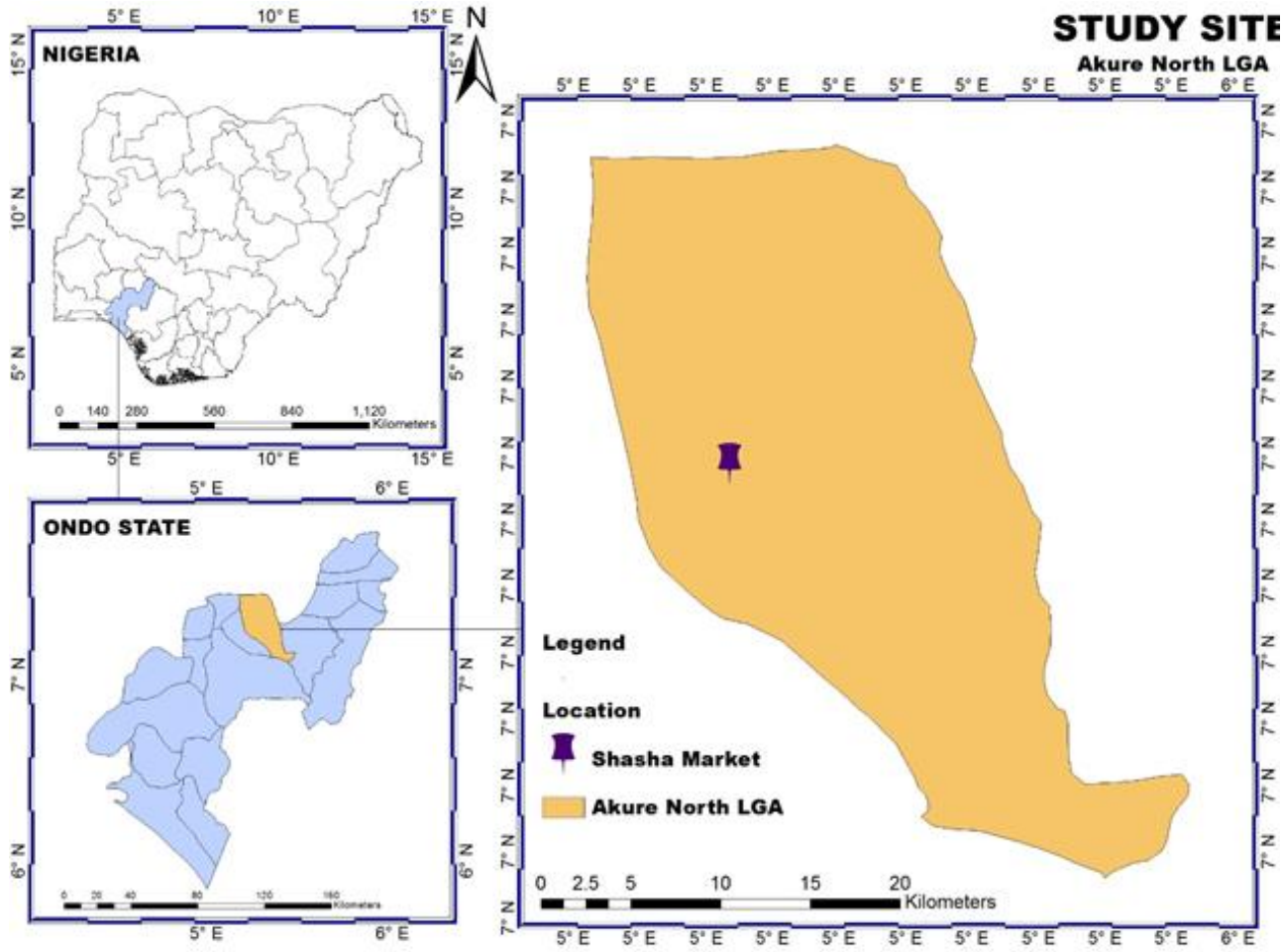

Figure 1. The study site.
Source: Oniya et al. (2022).

(Carrot and Tomato) samples were sourced and held in clean plastic containers from traders in the market and transported to the laboratory for analysis.

Analyses of samples

Samples of cooked rice and beans, sliced Carrot and Tomato and water samples were transferred aseptically into sterile beakers containing 200 ml of sterile water. Ten-fold serial dilutions of homogenates were made and 1 ml of the 10^{-4} dilutions of the homogenate was used for inoculation. 1 ml of 10^{-4} dilution factor was dispensed aseptically into sterilized Petri Dishes followed by pouring of sterile molten nutrient agar (NA), MacConkey agar, Deoxycholate Citrate Agar, Malt Extract agar, Mannitol Salt agar. The whole agar was swerved gently, allowed to solidify and later incubated at 37°C for 24 h. The procedure was repeated but with MacConkey agar, Deoxycholate Citrate Agar, Malt Extract agar, Mannitol Salt agar as media used. MacConkey agar was used for the isolation of coliforms, Mannitol Salt agar for isolation of *Staphylococcus aureus*, Deoxycholate Citrate Agar for isolation of *Salmonella and Shigella*, while Malt Extract Agar was used for isolation of fungi with incubation for 72 h at 28°. Air trapped in agar was also incubated for 24 and 72 h for bacteria and Fungi respectively. After incubation, counts (Colony Forming Unit/ml) were obtained for total heterotrophic bacteria, coliforms, fungi, *Salmonella, Shigella, Staphylococcus aureus* using colony counter. Also, spore forming unit (sfu/ml) was also obtained for fungi. Sub-culturing of discrete colonies followed on fresh choice media until pure cultures were obtained (Fawole and Oso, 2004), followed by gram staining procedure. Each isolate was then identified using their morphological characteristics as described by Olutiola et al. (2000) and their biochemical tests as described by Onuorah et al. (2015). Results of each bacterium identity were confirmed using Bergey's Manual of Determinative Microbiology as standard (Robert et al., 1957). The slides were viewed using oil immersion objective (x100) of the binocular microscope (Model HNB-107BN). The colonial and microscopic characteristics of the fungal isolates were determined using cotton-in-blue lactophenol technique. The slides were viewed using light microscope (Model HNB-107BN) under x10 and x40 objective lenses to observe for hyphae and spore mophology. Fungal isolates were then identified following the description of Oyeleke and Manga (2008). Modified Baermann's method was used for extraction of parasites larvae from the soil as described by Collender et al. (2015). Formol-Ether concentration method was employed in the detection of helminth's ova in the faecal samples. Following the recovery of eggs and/or larvae from the soil and faecal sample, identification was done using standard

Table 1. Soil sample collection points at market square and dump site.

Market Square				Dumpsite			
Location	**Coordinates**	**Location**	**Coordinates**	**Location**	**Coordinates**	**Location**	**Coordinates**
South	7°16'38.3"N 5°14'37.5"E	East	7°16'39.7"N 5°14'38.8"E	South	7°16'43.8"N 5°14'41.9"E	East	7°16'44.1"N 5°14'41.9"E
	7°16'38.4"N 5°14'38.5"E		7°16'41.6"N 5°14'38.6"E		7°16'43.6"N 5°14'42.2"E		7°16'44.0"N 5°14'42.0"E
	7°16'40.1"N 5°14'41.9"E		7°16'42.7"N 5°14'39.2"E		7°16'43.8"N 5°14'43.7"E		7°16'44.4"N 5°14'43.1"E
	7°16'41.3"N 5°14'42.8"E		7°16'44.9"N 5°14'40.5"E		7°16'43.6"N 5°14'44.8"E		7°16'44.4"N 5°14'44.2"E
	7°16'43.7"N 5°14'43.5"E		7°16'46.6"N 5°14'40.4"E		7°16'43.7"N 5°14'45.5"E		7°16'44.6"N 5°14'46.4"E
	7°16'44.3"N 5°14'45.8"E		7°16'48.8"N 5°14'41.7"E		7°16'43.3"N 5°14'47.8"E		7°16'44.8"N 5°14'47.7"E
North	7°16'38.5"N 5°14'36.1"E	West	7°16'37.2"N 5°14'38.7"E	North	7°16'43.5"N 5°14'46.1"E	West	7°16'43.2"N 5°14'41.7"E
	7°16'39.3"N 5°14'35.0"E		7°16'36.7"N 5°14'37.3"E		7°16'43.3"N 5°14'45.0"E		7°16'42.9"N 5°14'41.3"E
	7°16'40.4"N 5°14'34.9"E		7°16'35.7"N 5°14'36.8"E		7°16'43.4"N 5°14'44.9"E		7°16'41.7"N 5°14'41.8"E
	7°16'41.3"N 5°14'33.5"E		7°16'33.3"N 5°14'35.5"E		7°16'43.3"N 5°14'43.5"E		7°16'40.3"N 5°14'41.5"E
	7°16'42.6"N 5°14'32.4"E		7°16'32.4"N 5°14'33.7"E		7°16'43.6"N 5°14'41.3"E		7°16'38.3"N 5°14'41.7"E
	7°16'43.7"N 5°14'30.5"E		7°16'30.3"N 5°14'31.4"E		7°16'43.7"N 5°14'39.5"E		7°16'37.3"N 5°14'41.4"E

Source: Oniya et al. (2022).

keys (Chiodini et al., 2003; Zajac and Conboy, 2012).

Data analysis

Means of physico-chemical parameters soil and water, mean of microorganisms present in air, food, water and vegetables samples were determined using one-way analysis of variance (ANOVA). A probability level of $P<0.05$ was considered significant. Pearson correlation was used to analyse the relationship between physico-chemical parameters of water and microbial growth, soil and geohelminth prevalence. Statistical Package for Social Sciences (SPSS) version 21.0 software for windows was used for the analyses.

RESULTS

The physico-chemical parameters of soil samples at different points within the market and dumpsite environment revealed temperature values from 25.76 - 29.02°C (Tables 2 and 3) at both sampling sites with the highest temperature at the market square (29.02°C ± 0.73). The highest mean value for electrical conductivity was recorded at the south end of the dumpsite (2252.6 µS/cm ±1019.7). The pH values recorded at the market square were alkaline. Ova and larvae of parasites encountered included *Ascaris lumbricoides* (36.58%), hookworm larvae (13.75%) and *Strongyloides stercoralis* larvae (Table 4). From the result, it was observed that the soil samples at the west-end of the market square and dump site had highest number of total parasite count respectively (15.43 and 15.77%), while east end of the market square and south end of the dumpsite had the lowest parasite count (8.72 and 9.06%). 138 of 144 soil samples were contaminated which accounted for 95.83% of soil contamination. The correlation coefficients between soil physico-chemical parameters and geohelminths revealed that electrical conductivity had positive effect on hookworm larvae and ova (Table 5). On the other hand, temperature had negative correlation effect on *Strongyloides stercoralis* (-0.61) and *Ascaris lumbricoides* (-0.21). The correlation coefficients (r) between pH and hookworm larvae; hookworm ova and *Ascaris lumbricoides* ova were 0.70, 0.02, and 0.44, respectively. Hookworm larvae had a strong positive

Table 2. Mean of physico-chemical parameters of soil samples at different points within the market environment.

Location	EC (µS/cm)	Temp (°C)	pH	TDS (ppm)
North	732.22±181.23^{a}	29.02±0.73^{b}	8.29±0.17^{a}	387.67±205.74^{a}
South	453.89±217.87^{a}	28.27±0.14^{ab}	8.77±0.20^{a}	398.00±160.22^{a}
East	605.89±137.20^{a}	27.22±0.56^{ab}	8.05±0.33^{a}	605.89±137.20^{a}
West	749.61±133.59^{a}	26.68±0.18^{a}	8.34±0.23^{a}	749.61±133.59^{a}

Mean±Standard error represents three (3) replicates in all locations. Means having the same alphabet down the column are not significantly different from one another at p>0.05 using tukey's HSD.
Keys: EC- Electrical Conductivity; TDS-Total Dissolved Solid.
Source: Oniya et al. (2022).

Table 3. Mean of physico-chemical parameters of soil samples at different points around the dump site environment.

Location	EC (µS/cm)	Temp (°C)	Ph	TDS (ppm)
North	678.33±144.72^{a}	25.97±0.06^{a}	6.56±0.14^{ab}	283.61±32.73^{a}
South	2252.6±1019.7^{a}	25.76±0.26^{a}	7.85±0.20^{b}	1134.2±201.48^{c}
East	1121.1±243.65^{a}	26.19±0.43^{a}	5.36±0.95^{a}	902.84±116.77^{bc}
West	871.11±255.35^{a}	26.06±0.13^{a}	7.72±0.13^{b}	509.06±169.88^{ab}

Mean±Standard error represents three (3) replicates in all locations. Means having the same alphabet down the column are not significantly different from one another at p>0.05 using tukey's HSD.
Key: EC- Electrical Conductivity; TDS-Total Dissolved Solid.
Source: Oniya et al. (2022).

Table 4. Geohelminth ova and larvae contamination in soil samples from the study area.

Location	Cardinal direction	Number of samples examined	Number of contaminated soil (%)	Hookworm larvae (%)	Hookworm Ova (%)	*Stongyloides stercoralis* Larvae (%)	*Ascaris lumbricoides* Ova (%)	Total parasite count (%)
Market square	North	18	17(94.4)	15	7	2	12	36(12.75)
	South	18	18(100)	23	5	6	5	39 (13.08)
	East	18	18(100)	10	2	7	7	26(8.72)
	West	18	18(100)	12	7	12	15	46(15.43)
Dumpsite	North	18	16(88.8)	12	5	10	13	40(12.75)
	South	18	18(100)	17	6	7	7	37(12.41)
	East	18	15(83.33)	7	7	6	7	27(9.06)
	West	18	18(100)	13	2	15	17	47(15.77)
Total %		144	138(95.83)	109(36.58)	41(13.75)	65(21.82)	83(27.85)	298

Source: Oniya et al. (2022).

linear relationship to the alkaline nature of the soil. Out of 73 faecal samples that were examined, 69 (94.52%) were positive (Figure 2). Hookworm Ova had the highest prevalence (40%) followed by *S. stercoralis* and *Ascaris lumbricoides* which were 33 and 27%. There was no significant difference (p>0.05) in the temperatures of well water at all collection points (Table 6).

The correlation coefficients between the physico-chemical parameters and microbial growth of well water samples are presented in Table 7. The electrical conductivity (EC) values for *Staphylococcus aureus* (-0.54), *E. coli* (-0.51), *Klebsiella pneumonia* (-0.46), *S. typhi* (-0.19) implied that EC had negative correlation with the growth of these isolates. The temperature values for

Table 5. Correlation coefficients between soil physico-chemical parameters and geohelminths.

Variable	EC	Temp	pH	TDS	HKWL	HKWO	STRONG	*Ascaris lumbricoides*
EC	1							
Temp	-0.58	1						
pH	-0.18	0.56	1					
TDS	-0.83	-0.50	-0.21	1				
HKWL	0.21	0.44	0.70	-0.21	1			
HKWO	0.21	0.41	0.02	0.28	-0.11	1		
STRONG	-0.05	-0.64	-0.03	-0.01	0.67	-0.58	1	
Ascaris lumbricoides	-0.21	-0.21	0.44	-0.31	-0.27	-0.11	0.67	1

EC- Electrical Conductivity; Temp- Temperature; TDS- Total Dissolved Solid; HKWL- Hookworm Larvae;HKWO- Hookworm Ova; STRONG- *Strongyloides stercoralis.*
Source: Oniya et al. (2022).

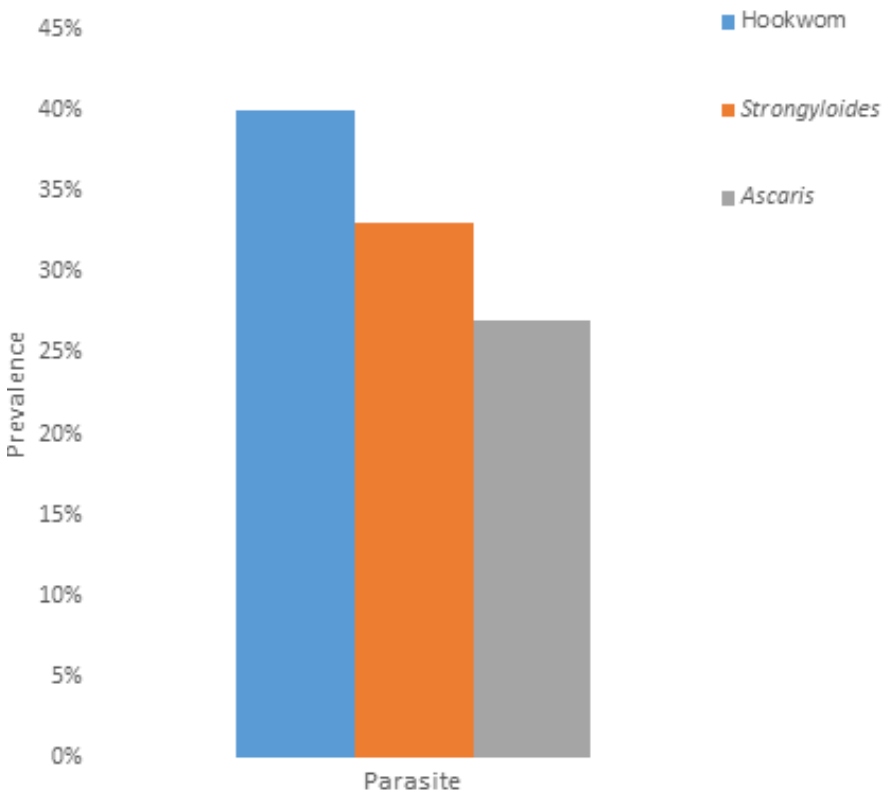

Figure 2. Prevalence of human intestinal helminths from faecal samples.
Source: Oniya et al. (2022).

Shigella sp (0.31), *Salmonella typhi* (0.23), *Staphylococcus aureus* (0.04), *E. coli* (0.05), *Streptococcus* spp (0.61) implied that temperature had a positive effect on the growth of microorganism. The dissolved oxygen (DO) values for *Shigella* sp (0.25), *Streptococcus* spp (0.06), *Staphylococcus aureus* (0.26), *Klebsiella pneumonia* (0.28), *Salmonella typhi* (0.03) implied that DO had a positive effect on microorganism growth (Table 7). Occurrence of isolates obtained from air, food, carrot, tomatoes and water samples showed that ten (10) bacteria and three (3) fungi were isolated (Table 8). Total heterotrophic bacteria count (cfu/g) in food, carrot, tomato samples and water samples (cfu/ml) from study site ranged from 0.00×10^4-3.03×10^6 CFU/g for test samples and 0.26×10^4-4.53×10^4 for air sample (Table 9). It was observed that tomatoes had the highest bacterial count. Total fungal counts (sfu/g) in food and vegetable samples are presented in Table 10 which ranged from 0.00×10^4-

Table 6. Physico-chemical parameters of well water samples at different spots of collection.

Spots	EC (µS/cm)	Temp (°C)	pH	TDS (ppm)	DO_2 (mg/l)	Turbidity (NTU)
1 (7°16'49.0'' N;5°14'40.6''E)	117.47±21.37^{ab}	26.63±0.44^{a}	6.73±0.21^{a}	100.00±9.84^{a}	5.73±0.06^{b}	43.76±0.12^{a}
2 (7°16'46.4''N;5°14'40.7''E)	101.47±19.30^{a}	26.93±0.34^{a}	6.87±0.24^{a}	91.33±18.44^{a}	6.30±0.05^{c}	44.30±0.36^{a}
3 (7°16'47.9''N;5°14'39.9''E)	229.67±5.48^{bc}	27.00±0.32^{a}	6.67±0.12^{a}	141.33±26.20^{a}	6.56±0.08^{c}	44.10±0.64^{a}
4 (7°16'43.2''N; 5°14'39.7''E)	294.67±57.51^{c}	26.73±0.49^{a}	6.76±0.06^{a}	162.67±53.76^{a}	5.16±0.08^{a}	45.76±0.91^{ab}
5 (7°16'44.5''N; 5°14'44.6''E)	222.33±6.12^{abc}	26.20±0.51^{a}	6.73±0.05^{a}	213.67±9.56^{a}	5.43±0.17^{ab}	46.40±0.36^{ab}
6 (7°16'44.3''N; 5°14'45.2''E)	168.00±5.50^{ab}	26.10±0.30^{a}	6.53±0.28^{a}	191.67±6.56^{a}	6.30±0.11^{c}	48.26±0.57^{b}

Mean ± Standard error represent three (3) replicates in all locations. Means having the same alphabet down the column are not significantly different from one another at p>0.05 using Tukey's HSD. EC- Electrical Conductivity; TDS-Total Dissolved Solid.
Source: Oniya et al. (2022).

Table 7. Correlation coefficients between physico-chemical parameters of water samples and bacterial growth.

Variable	EC	Temp	pH	TDS	DO_2	Turbidity
Shigella spp	0.24	0.31	-0.24	-0.05	0.25	0.41
Streptococcus spp	0.57*	0.61**	-0.01	0.07	0.06	-0.39
Staphylococcus aureus	-0.54*	0.04	0.15	-0.21	0.26	0.01
E. coli	-0.51	0.05	0.20	-0.17	-0.12	-0.26
Klebsiella pneumonia	-0.46	-0.19	0.23	-0.64	0.28	-0.31
S. typhi	-0.19	0.23	-0.14	-0.23	0.03	-0.11

*Correlation is significant at the 0.05. ** Correlation is significant at the 0.01.
Key: Temp- temperature; EC- electrical conductivity; TDS-Total Dissolved Solids; DO- dissolved Oxygen.
Source: Oniya et al. (2022).

6.23×10^4 and it was also observed that tomatoes had the highest fungal count.

Total coliform count and total *Salmonella-Shigella* count is presented in Tables 11 and 12 respectively. Coliforms were present in food, vegetables and water samples. *Salmonella and Shigella* were not detected in rice, beans, carrot and tomato but were present in some well water samples (spots C to F) and ranged from 1.20×10^4 - 3.00×10^4cfu/ml. The highest *Salmonella-Shigella* count (7.66×10^4 cfu/m^3) was recorded in air sample at the centre of the market. Total *Staphylococcus* counts of test samples (Table 13) from six different vendors in the study site revealed no growth in carrot, while other test samples had *Staphylococcus* growth present in one or more samples. Air sample at the centre of the market had the highest *Staphylococcus* growth count (2.33×10^4 CFU/m^3).

DISCUSSION

The research assessed the health implications of visitors and buyers attending Shasha Market, Akure, a daily perishable goods and food market. The environment was highly contaminated with various micro and macro organisms of public health importance. The market displayed poor sanitation as soil samples from all the premises harboured one parasite stage or the other with hookworm larvae accounting for 36.58% of stages found, and seen in all soil samples across the twenty-four (24) points of collection. Similar findings are in literature (Edelduok et al., 2013; Ohiolei et al., 2017; Jourdan et al., 2018; Hassan and Oyebamiji, 2018; Oniya, 2019; WHO, 2019; Simon-Oke, 2020). The result revealed that 95.83% of the collected soil samples were contaminated with parasite eggs/ larvae as equally observed by Ojurongbe et al. (2014) in Nigeria, who also penned that there is extreme contamination of soils by these organisms across the globe. The risk of contracting infection in the Market square may be higher than the dumpsite area. The two sites from which soils were sampled in the market predisposed buyers, sellers and dwellers to infection. Therefore, infections could be easily contracted by contamination of hands, having body contact with people or walking barefooted. The high prevalence of hookworm observed in this study may have been favoured by physical and chemical composition of the soil, poor hygiene, and indiscriminate disposal of faeces. This observation is in line with findings of Brooker et al. (2006) in Sub-Saharan Africa. The widespread contamination of soil with eggs and larvae of human intestinal parasites is epidemiologically significant. The recovery of geohelminths ova from refuse dumpsites

Table 8. Occurrence of isolates obtained from test samples.

Isolates	Rice	Beans	Carrot	Tomatoes	Well water	Air
Escherichia coli	+	+	+	+	+	−
Bacillus cereus	+	−	+	+	−	−
Staphylococcus aureus	+	+	−	+	+	+
Streptococcus spp	−	−	−	+	+	−
Serratia marcescens	−	−	+	−	−	+
Klebsiella pneumonia	+	+	−	+	+	+
Vibrio cholerae	−	+	−	+	−	−
Pseudomonas aeruginosa	−	+	−	−	−	−
Shigella spp	−		−	−	+	+
Aspergillus niger	−	+	+	+	−	+
Salmonella typhi	−	−	−	−	+	−
Rhizopus stolonifera	+	−	+	−	−	−
Penicillium digitatum	−	−	+	+	−	+

- Absent ; + Present.
Source: Oniya et al. (2022).

Table 9. Total heterotrophic bacteria counts in food, vegetable and water samples.

Samples from different vendors	(CFU/g)				(CFU/ml)	(CFU/m^3)
	Beans	Rice	Carrot	Tomato	Water	Air
A	1.44×10^{6c}	0.17×10^{6ab}	0.34×10^{6a}	3.03×10^{6ab}	0.22×10^{5a}	3.03×10^{4} (market entrance)
B	0.25×10^{6b}	0.24×10^{6b}	0.35×10^{6a}	0.71×10^{6c}	0.39×10^{5a}	
C	0.12×10^{6a}	0.56×10^{6ab}	0.36×10^{6a}	0.43×10^{6ab}	0.46×10^{5a}	4.53×10^{4} (market centre)
D	0.39×10^{4c}	1.16×10^{6a}	0.26×10^{6a}	2.16×10^{5a}	0.39×10^{5a}	
E	0.11×10^{4a}	0.41×10^{6c}	0.16×10^{6a}	2.43×10^{5a}	0.52×10^{5a}	0.26×10^{4} (market rear)
F	0.6×10^{5a}	0.20×10^{6ab}	0.29×10^{6a}	2.63×10^{5a}	0.71×10^{5a}	

Mean ± Standard error represent three (3) replicates in all locations. Means having the same alphabet down the column are not significantly different from one another at p>0.05 using tukey's HSD. Each sample was sourced from different vendors.
Source: Oniya et al. (2022).

revealed indiscriminate faecal disposal as equally observed by Ugbomoiko et al. (2006), Nwoke et al. (2013) and Dada and Egbunu (2016) all in various parts of Nigeria. The prevalence of *Strongyloides stercoralis* as observed by Hotez et al. (2003) in United States of America, may be influenced by moisture films of contaminated soils which show favourable condition for viability of the eggs until contact with suitable host is made. Similar observations have been previously reported in Nigeria (Ogbolu et al., 2011; Dada, 2015; Dada and Egbunu, 2016).

The temperature ranges from 25.76 ± 0.26°C and 29.02 ± 0.73°C, favoured the embryonation of soil transmitted helminths eggs (Amadi and Uttah, 2010; Owhoeli et al., 2017). The high temperature of the market square compared to dumpsite area could be due to the activities of the traders and buyers in the market square and this in turn may affect the electrical conductivity of the soil. The pH of soil samples was slightly acidic tending towards the neutral point which is equally suitable for the development of the organisms. The pH range observed was favourable for development of parasite stages as reported elsewhere in Nigeria (Obiukwu et al., 2008; Simon-Oke, 2020). The mean electrical conductivity (EC) of the dumpsite soil (1696.00µS/cm) was low when compared with the findings of Badmus et al. (2014) in some major areas of Western Nigeria. The electrical conductivity and total dissolved solids of soil samples in the study area were relatively high, this is as a result of various activities ranging from metal work, stone work, washing, burning of refuse and various forms of other socio-economic activities in the study area. The electrical conductivity of soil samples in the dumpsite area which ranged from 678.33 µS/cm -2252.6 µS/cm were critical and not favourable for germination of crops and agricultural practices because EC is an indicator of soil health and excessive salt hinders plant growth by affecting soil water balance (Uma et al., 2016). The

Table 10. Total fungal counts in foods and vegetables.

Samples from different vendors	(SFU/g)				(SFU/m^3)
	Beans	Rice	Carrot	Tomato	Air
A	0.00×10^{4c}	2.13×10^{4ab}	0.00×10^{4a}	0.00×10^{4ab}	0.10×10^4 (market entrance)
B	1.33×10^{4b}	$0.00\times10^{4\ b}$	2.33×10^{4a}	3.33×10^{4c}	
C	3.00×10^{4a}	$3.00\times10^{4a\ b}$	2.03×10^{4a}	6.23×10^{4ab}	0.20×10^4 (market centre)
D	0.00×10^{4c}	1.16×10^{4a}	3.00×10^{4a}	0.00×10^{4a}	
E	0.00×10^{4a}	0.00×10^{4c}	1.65×10^{4a}	0.00×10^{4a}	0.13×10^4 (market rear)
F	3.33×10^{4a}	0.00×10^{4ab}	1.00×10^{4a}	4.23×10^{4a}	

Mean ± Standard error represent three (3) replicates in all locations. Means having the same alphabet down the column are not significantly different from one another at p>0.05 using tukey's HSD. Each sample was sourced from different vendors.
Source: Oniya et al. (2022).

Table 11. Total coliform counts in food, vegetables and water samples.

Samples from different vendors	(CFU/g)				(CFU/ml)
	Beans	Rice	Carrot	Tomato	Water
A	0.40×10^4	1.40×10^4	0.60×10^4	0.00×10^4	0.40×10^4
B	0.00×10^4	0.00×10^4	0.00×10^4	1.00×10^4	0.60×10^4
C	0.00×10^4	1.00×10^4	0.40×10^4	0.60×10^4	0.20×10^4
D	0.60×10^4	0.60×10^4	0.20×10^4	0.00×10^4	1.00×10^4
E	0.00×10^4	0.00×10^4	0.60×10^4	0.20×10^4	0.40×10^4
F	0.20×10^4	0.20×10^4	0.00×10^4	0.16×10^4	1.00×10^4

Mean ± Standard error represent three (3) replicates in all locations. Means having the same alphabet down the column are not significantly different from one another at p>0.05 using tukey's HSD. Each sample was sourced from different vendors.
Source: Oniya et al. (2022).

prevalence of intestinal helminthiasis from faecal samples is 94.52%, and thus calls for intervention taking into consideration probable morbidities.

The pHs of all the well water samples were near neutral. The pH range (6.53 - 6.87) obtained in this study is within the acceptable level of 6.0 to 8.5 with the mean value of 6.71 ± 0.05. These results were similar to the findings of Charkhabi and Sakizadeh (2006), carried out in Siahroud River, Iran. The temperature range of well water samples fell within WHO permissible limit of 23 to 40°C, the temperature recorded could be said to be suitable for the growth of heterotrophic bacterial species (Pelczar et al., 2005; Akinbile and Olatunji, 2018). Turbidity varied from 43.76 - 48.26NTU which was above the WHO standard values of 5 NTU. Elsokkary and Abukila (2014) also reported similar values in Ogbese River, Ondo State, Nigeria. Turbidity of water is caused mainly by the presence of suspended matter, such as clay, silt, colloidal organic particles, plankton and other microscopic organisms that obstruct light transmission through water bodies (WHO, 2011). These colloidal materials provide adsorption sites for chemicals that may be harmful to health or cause undesirable tastes or odours (WHO, 2004; Adekunle et al., 2007). The implications of low dissolved oxygen are that the water would not be suitable for public/domestic supply and recreational purposes, and that it would weaken the activities of aquatic organisms and the DO reduction will also prevent the establishment or distortion of the usual flora and fauna. DO has a positive effect on bacteria growth (Adekunle et al., 2007). The EC of well water samples ranged from 101.47-294.67µS/cm with mean value of 188.94 µS/cm ± 30.08 which is within the WHO permissible value of 250µS/cm.

The distributions of the bacterial isolates in the well water samples varied according to the environment surrounding the wells. *Escherichia coli* was predominant in all the wells sampled. The possible contamination ways could be by poor hygiene, lack of treatment scheme for the water and every other dirt-oriented marketing activity around the wells. The presence of coliforms in the wells may be suggestive of earlier pollution because coliforms survive for long in polluted soil, water and vegetation (Agunwamba, 2000; Hussein, 2007; Mboto et al., 2012). The wells closest to the dumpsite (well water E and well water F) had the highest TDS and bacterial count. These values show the effect of the dumpsite on the well, as also observed by Owoeye and Akinneye

Table 12. Total salmonella-shigella counts in food, vegetables, water and air samples.

Samples from different vendors	(CFU/g)			(CFU/ml)		(CFU/m^3)
	Beans	Rice	Carrot	Tomato	Water	Air
A	0.00×10^4	0.00×10^4	0.00×10^4	0.00×10^4	0.00×10^4	3.33×10^4 (market entrance)
B	0.00×10^4	0.00×10^4	0.00×10^4	0.00×10^4	0.00×10^4	
C	0.00×10^4	0.00×10^4	0.00×10^4	0.00×10^4	3.00×10^4	7.66×10^4 (market centre)
D	0.00×10^4	0.00×10^4	0.00×10^4	0.00×10^4	2.00×10^4	
E	0.00×10^4	0.00×10^4	0.00×10^4	0.00×10^4	1.33×10^4	6.66×10^4 (market rear)
F	0.00×10^4	0.00×10^4	0.00×10^4	0.00×10^4	1.20×10^4	

Mean ± Standard error represent three (3) replicates in all locations. Means having the same alphabet down the column are not significantly different from one another at p>0.05 using tukey's HSD. Each sample was sourced from different vendors.
Source: Oniya et al. (2022).

Table 13. Total *staphylococcus* count in food, vegetables, water, air samples.

Samples from different vendors	(CFU/g)				(CFU/ml)	(CFU/m^3)
	Beans	Rice	Carrot	Tomato	Water	Air
A	0.40×10^{4b}	0.00×10^{4a}	0.00×10^{4a}	0.60×10^{4b}	0.20×10^{4b}	1.00×10^4 (market entrance)
B	0.00×10^{4a}	0.60×10^{4b}	0.00×10^{4a}	0.00×10^{4a}	0.40×10^{4b}	
C	0.00×10^{4a}	0.00×10^{4a}	0.00×10^{4a}	0.00×10^{4a}	0.00×10^{4a}	2.33×10^4 (market centre)
D	0.00×10^{4a}	0.00×10^{4a}	0.00×10^{4a}	0.00×10^{4a}	3.00×10^{4c}	
E	0.00×10^{4a}	0.40×10^{4b}	0.00×10^{4a}	0.00×10^{4a}	0.00×10^{4a}	1.23×10^4 (market rear)
F	0.00×10^{4a}	0.00×10^{4a}	0.00×10^{4a}	0.00×10^{4a}	0.00×10^{4a}	

Mean ± Standard error represent three (3) replicates in all locations. Means having the same alphabet down the column are not significantly different from one another at p>0.05 using tukey's HSD. Each sample was sourced from different vendors.
Source: Oniya et al. (2022).

(2018) in dumpsites around in Akure, Nigeria. *E. coli* and *Klebsiella pneumonia* were isolated in cooked rice and bean samples. Likewise the presence of *Staphylococcus auerus*, a pathogenic microorganism of public health concern in these ready-to-eat foods may have ominous health implications and such foods may have been contaminated as a result of handling by processors (Dunn et al*.,* 1995; Jay*,* 2000; Adebolu and Ifesan, 2001; Li-Cohen, 2002; Omemu and Bankole, 2005). The greatest danger associated with water used for food processing, drinking purposes and human use is contamination by human excrement (Edema et al*.,* 2001; Okonko et al*.,* 2008).

Many viruses, bacteria and protozoans on vegetables which can cause food poisoning are derived from human faeces. Carrot is a root vegetable which contains the important biological active compound carotenoid (Al-Hindi et al., 2011). Three species of bacteria were isolated from the cultured carrots obtained from Shasha Market. They were characterized and identified as *Escherichia coli, Serratia marcescens* and *Bacillus cereus*. *Escherichia coli* was the most occurring of the three as also shown by Adebayo-Tayo et al. (2012) in Uyo Metropolis of Nigeria. The moulds isolated from carrots were *Penicillium digitatum, Rhizopus stolonifera and Aspergillus niger.* Bacteria isolated from fresh tomatoes were *Vibrio cholerae, Staphylococcus aureus*, *Bacillus cereus, Klebsiella pneumonia*, *Escherichia coli, Streptococcus*. In most developing countries, microbial infection of tomatoes can occur during the harvesting period, postharvest handling, storage, transportation, and processing by customers (Baiyewu et al., 2007; Barth et al., 2009). *Klebsiella pneumonia* are ubiquitous organisms that can be found in the environment (Brisse et al*.,* 2006; Pigott, 2008) and could have gained access to the tomatoes during postharvest period as reported by Etebu et al. (2013) in Kwara and Oyo axis of Nigeria and Lemma et al. (2014) in Europe. *Bacillus* sp. are resistant to high temperatures of the sun's ultraviolet rays because of the endospores, hence their bacterial load in the tomatoes. There was no *Shigella* sp recorded from all tomatoes samples, a finding earlier reported by Adebayo-Tayo et al. (2012)

Conclusion

The study has revealed the potential health risk of

contracting intestinal helminth parasites and micro-organisms in the soil, air, water and food samples in open market systems. The presence of *A. niger* and *V. cholerae* are of serious public health concern. The state government needs to construct good access roads, provide potable water and as a matter of urgency address the hygiene and sanitation requirements of the busy market.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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