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Full Length Research Paper

The Potential Health Hazards Associated With Waste Scavenging in Ghana: A Case Study of Three Selected Dumpsites in Tema Metropolis

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Abstract

The health implications of waste scavenging in solid waste management in Tema metropolis, Ghana, has been a cause of concern as no proper attention has been given to the scavengers. To isolate, characterize and identify pathogens associated with municipal waste that may be of public health importance; samples were collected from three dumpsites in Tema, Ghana. Serial dilutions of the samples were carried out and aliquots (1 ml) of the diluted samples were inoculated onto appropriate media. Similarly, hands of waste scavengers were swabbed prior and during scavenging, as well as PCA and PDA plates exposed at the dumpsites for microbial analysis. Biochemical test was carried out to identify the particular types of bacteria isolated. The study revealed eleven genera of bacteria and four genera of fungi. It was inferred from this study that microbial load at waste dumpsites poses a great threat not only to waste scavengers but also to the society as well, as scavengers serve as routes for the transmission of certain pathogens associated with waste to the larger society, thereby, constituting some public health hazards. The paper recommended that proper personal protection of the scavengers and integrating this informal sector into waste management planning, building on their practices and experiences while working to improve efficiency, living and working conditions of the scavengers should be encouraged.

Keywords: Health Hazards, Municipal Solid Waste, Dumpsites, Scavengers, Tema Metropolis, Ghana.

INTRODUCTION

Waste refers to substances or objects which are disposed off or are intended to be disposed off or are required to be disposed off by the provisions of national law (Basel Convention, 1992). The daily activities of humans give rise to a large variety of wastes and when these waste materials are disposed off, microorganisms of different types such as bacteria, fungi and worms (helminthes) colonize the waste and begin to degrade them (Wachukwu *et al*., 2010). As a result, they break down the unprocessed or organic components of waste into inorganic forms, which can readily serve as sources of nutrients for a variety of other organisms. Some of these pathogens are potential human pathogens such as *Aspergillus fumigatus, Escherichia coli, Klebsiella pneumonia and Salmonella sp.* and may cause severe health hazards (Falomo, 1995). They must therefore be managed properly to reduce or prevent its associated hazards.

Although other methods of waste disposal such as engineered landfill and composting are available, open dumping continues to be the prevalent method available in Ghana, particularly, in major cities like Accra and Tema even though these are strongly discouraged in the National Sanitation Policy (Anthony, 2005). The improper disposal of these waste constitute serious health problems, such as transmission of infectious diseases to humans and animals living within the vicinity (Lorentz *et al*., 2000), as they pollute the air, soil and freshwater bodies. Again, in developing countries, the incinerators

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are not properly sited and lack proper emission control facilities which are important in limiting exposure of humans to air pollution produced as a result of incineration of solid waste. The most serious threat with landfills is that they are associated with leachates generated within the waste which subsequently infiltrate into unconfined aquifers below or adjacent to disposal sites.

During the activities of scavengers (individuals who make a living by foraging the waste for survival), they are exposed to various infectious agents (Ray *et al*., 2004) as well as to various toxic substances which may cause illness/sickness. They are also exposed to potentially pathogenic bio-aerosols that may lead to the spread of various diseases. Research conducted by Douwes *et al.* (2003) revealed that exposures to bioaeroslos in both the occupational and residential indoor environment could have adverse effects with major public health impact, including contagious infectious diseases, acute toxic effects, allergies and cancer. Another effect is that these scavengers are exposed to inhalation of infected dust, skin contact with infected materials, bites from disease-transmitting insects and animals, and occasionally accidental burns or injuries from various kinds of accident. It is therefore imperative that the health concerns associated with waste dumps are addressed bringing to bare the microbial load burden on the dumps. The objective of the study, therefore, was to assess the potential health hazards associated with scavenging in the Tema metropolis, Ghana.

MATERIALS AND METHODS

Study Area

The research was conducted in Tema metropolis in the Greater Accra region of Ghana. Tema is a metropolitan city on the Atlantic coast of Ghana, lying 25 kilometres east of the Ghanaian capital city, Accra. It has a land area of 368.3 sq. km and an estimated population of 209,000 people (Population and Housing Census, 2000). It is highly industrialized and occupied by people from different ethnic groups, both Ghanaians and foreigners. The dumpsites are located at different parts of the city, one at Kpone, Ashaiman and Tema Community 1 (Figure 1).

Kpone dumpsite

Kpone Katamanso sub-metropolitan area is a *suburb of Tema metropolis* in the Greater Accra Region of Ghana. The waste dumpsite is located approximately 15km from the Tema town center on the Tema Aflao road. It has a size of about 10 acres and shares a common boundary east of the free zone enclave. It receives a total volume of about 150.6 tons waste per day. The major economic activity in the town is fishing but with the polarization of industries there are also industrial workers.

Tema Community 1

Tema Community 1 is the central business district of the Tema metropolis. The residents are petty traders, artisans, tradesmen and professionals. The dumpsite is located in the community 1 market, locally and popularly referred to as “Kwasia guaso” near the Presby Church or the Goil filling station with a size less than one acre. It is a transfer station for solid waste, as waste dumped there is later collected and carried away to be disposed at the Kpone dumpsite.

Ashaiman

Ashaiman is located about four kilometres to the north of Tema and about 30 kilometres from Accra, the capital of Ghana, and shares boundaries on the north and east with the Katamanso Zonal Council of the TMA, on the south with the Tema town center, and on the west with Adjei Kodjo, a community which forms part of Tema Zonal Council.

Many of the earlier settlements under flood-prone conditions have been turned into urban slums where poor migrants moved in from the northern part of Ghana and other neighbouring countries to settle. Consequently, it is the most densely populated municipality in Accra with a population of 217,717 and an average household size of five (Ashaiman Municipal Assembly).

The Ghana year 2000 Population Census Report estimated the population of Ashaiman to be 150,312 with a growth rate of 4.6 per cent, which is higher than the 2.6 per cent national growth rate. The dumpsite with an average size of less than one acre of land is located in the light industrial area on the old Accra-Ada road.

Ethical Consideration

Ethical clearance was sought from the Tema Waste Management Division and the Tema Health Directorate prior to the collection of samples from scavengers. An informal consent was also sought directly by meeting with the various waste scavengers to willingly volunteer to be part of this study. It entailed the purpose of the study, benefits, privacy/confidentiality and conflict of interest. Participation was absolutely voluntary and each subject had the opportunity to participate or opt out at any point in the course of the survey.

Sampling

The sampling method used was a Convenient Sampling

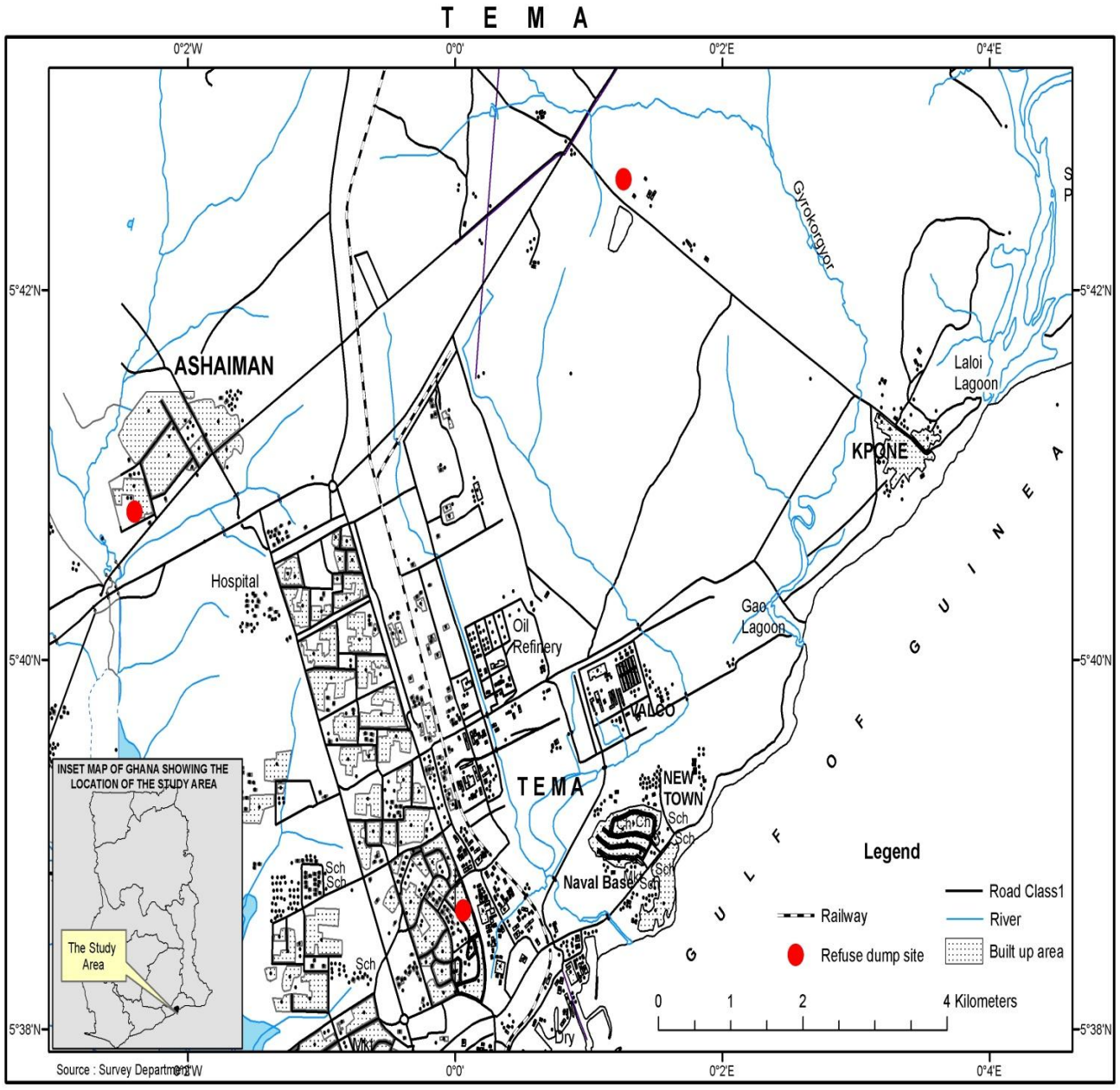

Figure 1. Map of Tema showing locations of dumpsites

Technique, a non-probability sampling technique where the subjects are selected based on convenience, accessibility, proximity to the researcher and not necessarily a representative of the entire population (Adèr et al., 2008).

Research Period and Sample Population

The study was carried out between August 2010 and June 2011, using scavengers within the age bracket of 10-65 years and Control subjects of same age bracket who were also scavengers. A total of 100 scavengers with 40 Control subjects, 3 dumpsites mostly solid wastes, were used for the study. The low number of Control subjects was as a result of the non-compliance of most of the scavengers to allow collection of samples from them, despite incentives provided for them.

Waste Dump Sites

There were so many of the waste dumpsites in the Tema metropolis. Therefore, the three dumpsites used for the studies were conveniently selected based on where majority of the scavengers were located most of the time.

Scavengers

The study population was a total of one hundred (100) scavengers. Since there were no existing data on the total number of scavengers in the Tema metropolis, the entire population of the scavengers in Tema was estimated to be a little over 300 according to the Tema Municipal Assembly. Based on this assumption of the total number of scavengers present, 54 from Kpone, 26 from Ashaiman and 20 from Tema Community 1, were chosen to make a total of 100 scavengers.

Collection of samples and Enumeration of bacteria

Samples collected include waste samples, air propagules and hand swabs from scavengers which were subjected to microbiological analysis.

Waste Samples

Sample collection began first week in the month of November, 2010. A total of 3 samples (30 kg) were collected, one from each dump site during the sampling period. At each sampling station, the surface debris was removed and subsurface soil dug to a depth of about 5 cm and scooped from demarcated sections on the dump site and mixed thoroughly. Waste heap was further divided into two and remixed of which a representative sample of 100 g was taken. The mixing of the waste sample was for even distribution of microbes and to ensure that a sizeable number of organisms are collected and not missed. Soil samples were immediately sieved through a 0.2mm wire mesh to obtain fine soil particles (U.S. EPA, 1978). Hundred grams (100 g) of each air-dried fine soil sample was mixed in a sterile container containing 250ml of sterile distilled water using a sterile glass rod. Sampling bottles were appropriately labelled and transported in ice chest to the laboratory for analysis. Samples were kept in the freezer to slow all activities of the organisms till the next day before analysis.

Airborne bacteria and fungi

Along with waste collection, propagules of microbes in air were collected monthly and recorded over a period of three months in and around the dumpsites. On each of the three occasions, air sampling of viable propagules was carried out. A total of 3 samples were collected in the three communities using the Plate Exposure Technique as described by Robert Koch (2003). Fungal or bacterial propagules were allowed to settle, with the help of air currents and force of gravity, onto plates containing freshly prepared Potato Dextrose Agar (PDA) and Plate Count Agar (PCA) media exposed for 10 minutes, and incubated at 35^{o}C for 48 hours. Colonies formed (CFU) were counted to show the number of settled bacterial or fungal propagules. Further identification was done after 3 days of incubation to determine the type of microorganism present, based on their morphological and biochemical properties (Benson, 2002; Pelczar *et al*., 1993).

Hand swab

Sterile swab sticks were passed on the hands of twenty (40) waste scavengers prior to the start of work early in the morning after their hands had been washed with soap and distilled water, and repeated during scavenging just to ensure that the microbes that were identified were not picked from elsewhere other than the dumpsite. The swabs were put into Amies transport medium and capped securely (Ballows and Herman, 1990). Thereafter, the hand swabs were inoculated on Potato Dextrose Agar and MacConkey Agar plates and incubated at 37 °C for 24hour.

Waste scavengers

Samples collected from scavengers were hand swabs only.

Data Analysis

Data obtained from microbiological test of the waste samples were analysed using STATA version 11 software. The various data were subjected to Pearson chi-square statistics and Analysis of Variance (ANOVA). The descriptive data were given as a Mean±Standard Deviation (SD) and percentages. Colony forming units (CFU) were recorded for bacteria on PCA (37ºC), Mc (37ºC), Mc (44ºC) and PDA (37ºC). The colony forming units were determined by using Harley and Prescott (1990) formula:

$$Number of bacteria / gram = average number of colonies \times \frac{1}{dilution factor}$$

Microbial Analysis

Preparation of media

The various types of agar used for the bacteria and fungi culture from the waste samples were Oxoid products of MacConkey (CM005), Potato Dextrose Agar (PDA), Plate Count Agar (PCA) and already prepared Uri-Select in the laboratory (a chromogenic media). API 20E system was used for further identification of the bacteria present in the samples. Amies transport media was used to

transport swabs obtained from scavengers from the waste dumpsite to the laboratory for analysis. The media used were all prepared by adhering to the manufacturer's specifications.

Potato Dextrose Agar (PDA)

The Potato Dextrose Agar was used for the cultivation and enumeration of yeasts and moulds. For the preparation of the media, 39 g of PDA powder was suspend in 1 L of distilled water in a glass bottle with cap and mixed thoroughly. The mixture was heated with frequent agitation and allowed to boil for 1 minute to completely dissolve the powder. The mixture was autoclaved at 121^0C for 15 minutes. 0.1 ml aliquots of the specimen were dispensed onto each petri dish. Using the standard pour plate technique, the cooled mixture was poured into the sterile petri dishes containing the specimen to obtain isolated colonies after which they were covered and allow to solidify for a minimum of 30 minutes. The plates were incubated at room temperature in an inverted position (agar side up) with increased humidity. The colonies in pour plates were counted and the results expressed as yeast and moulds counts per gram or millilitre of material, taking into account the applicable dilution factor. The medium was acidified to pH 3.5 by adding 1ml of Lactic Acid 10% SR0021 to each 100ml of sterilised medium at 50°C in order to suppress bacterial growth (MacFaddin, 1985)

Plate Count Agar (PCA)

Plate count agar (PCA), 23.5g agar; 1L distilled water. The PCA (11.8g) was suspended in a 500ml conical flask containing 500ml distilled water which was plugged with non-absorbent cotton wool. The agar was allowed to soak and placed on fire until dissolved and autoclaved at 121℃ for fifteen minutes. The PCA was cooled in a water bath to about 48-50℃.

MacConkey Agar (CM007)

40 g of MacConkey agar was suspended in 1 litre of distilled water. The mixture was allowed to boil to dissolve the agar completely. The mixture was sterilised by autoclaving at 121°C for 15 minutes after which the surface of the gel was dried before inoculation. 0.1 ml aliquots of the specimen was dispensed onto each petri dish and with a standard pour plate technique, the cooled mixture was poured into the sterile petri dishes containing the specimen after which they were covered and allow to solidify for a minimum of 30 minutes. The plates were incubated at room temperature in an inverted position (agar side up) to obtain isolated colonies.

Amies Transport Media

20 g of the powder was suspended in 1 litre of purified water and mixed thoroughly. The mixture was heated with frequent agitation and boiled for 1 minute to completely dissolve the powder. The solution was black and opaque. 10 ml of the mixture was taken and dispensed into 6-8 mL screw-cap vials to within 5 mm of the top and capped tightly. The capped test tubes were autoclaved at 121°C for 15 minutes to a semi-solid medium. The swabs were placed in the medium and incubated at room temperature for 18-24hrs. The swabs were later removed and streaked on prepared Uri-Select and Plate Count Agar and incubated appropriately. All cultures were viable.

API 20E TEST

API 20E test strip manufactured by bioMerieux, Inc., consisted of a plastic strip of 20 individual test tubes or cupules each containing a different reagent used to determine the metabolic capabilities, and, ultimately, the genus and species of enteric bacteria in the family Enterobacteraceae. Each cupule was inoculated with a saline suspension of a pure bacterial culture, rehydrating the dried reagent in each tube. Some of the tubes were to be completely filled (tests CIT, VP and GEL), whereas others are topped off with mineral oil so that the anaerobic reactions (reactions that occur in the absence of oxygen) could be carried out (tests ADH, LDC, ODC, H2S, URE).

The strip was then incubated in a small, plastic humidity chamber for 18-24 hours at 37°C. The living bacteria produced metabolites and wastes as part of the business of being a functioning cell. The reagents in the cupules were specifically designed to test for the presence of products of bacterial metabolism specific to certain kinds of bacteria. After incubation, each tube (an individual test) was assessed for a specific colour change indicating the presence of a metabolic reaction that shed light on the microbes' identity. Some of the cupules contents changed colour due to pH differences, others contained end products that had to be identified using additional reagents.

The 20 reactions interpreted, in addition to the oxidase reaction (which was done separately), were converted to a seven-digit code and the code looked up in a huge manual that had the names of bacterial species associated with each seven-digit string of numbers and the names recorded as such.

Culturing and Enumeration of Bacteria

1 ml (10ml of sterilised distilled water was added to 1g of solid waste) of each prepared waste sample was added

into 9 ml of 0.1% bacteriological peptone (10^{-1} dilution). An aliquot (1.0 ml) was transferred into the next test tubes and diluted serially in one-tenth stepwise to 10^{-3} dilution using sterile pipettes (Paul and Clark, 1998). From the dilution of 10^{-1}, 10^{-2} and 10^{-3} of each sample, 0.1 ml aliquot was transferred aseptically onto the Petri dishes and thereafter, using a Pour Plate method, freshly prepared media of MacConkey, Potato Dextrose agar (PDA) and Plate Count agar (PCA) were added to sample, mixed in a clockwise and anticlockwise manner and allowed to solidify. The inoculated plates were inverted and incubated at 37^0C for 24-48 hours after which plates were examined for growth.

Isolation, Characterization and Identification of Bacteria in the Waste Dump Site

Pure cultures of bacteria were obtained by aseptically streaking representative colonies of different morphological types which appeared on cultured plates unto freshly prepared Uri-Select (a chromogenic media) using a sterile inoculation loop and incubated at 37 ^{0}C for 24 hrs. These served as pure stock cultures for subsequent characterization tests.

Pure cultures were identified on the basis of their morphological and physiological characteristics in accordance with methods prescribed by Cruickshank et al. (1975), and with reference to Holt (1977). Isolates from pure cultures were Gram stained and based on the Gram stain reaction, a biochemical test (API) was done to identify and confirm the particular individual organisms present. The unknown bacteria were identified by searching through a book, Analytical Profile Index, and searching for the number corresponding to the unknown. The colonies which developed were recorded as total viable fungi in the sample (CFU)

Culturing and Enumeration of Fungi

1 ml (10ml of sterilised distilled water was added to 1g of solid waste) of each prepared waste sample was added into 9 ml of 0.1% bacteriological peptone (10^{-1} dilution). An aliquot (1.0ml) was transferred into the next test tubes and diluted serially in one-tenth stepwise to 10^{-3} dilution using sterile pipettes (Paul and Clark, 1998). From the dilution of 10^{-1}, 10^{-2} and 10^{-3} of each soil sample, 0.1 ml aliquot was transferred aseptically onto freshly prepared Potato Dextrose Agar (PDA) plates of which 0.2 ml of 0.5% Ampicillin was added to inhibit the growth of bacteria and allowing the growth of fungi (Harrigan and McCance, 1990) the inoculums was spread with a sterile bent glass rod. The inoculated plates were inverted and incubated at 280C (room temperature) for 5 to 7 days. The colonies which developed were recorded as total viable fungi in the sample (CFU).

Isolation, Characterization and Identification of Fungi in Waste Dump Site

Pure cultures were obtained by sub culturing discrete colonies onto freshly prepared Potato Dextrose Agar plates and inoculated at 28 ^{0}C for 5 to 7 days. The isolates which developed were stored in the refrigerator as stock cultures for subsequent characterization test.

RESULTS AND DISCUSSION

Microbial Isolates from Scavengers, Air and Solid Waste Samples

The results obtained from the scavengers while working were compared with the results obtained from them prior to work (control). From the waste dumpsites, the bacteria isolated were *Enterococcus faecalis*, *Bacillus sp., Klebsiella pneumoniae, Enterobacter amnigenus, Proteus mirabilis, Escherichia coli*, *Citrobacter freundi, Pseudomonas aeruginosa and Salmonella* sp. The most frequently encountered bacteria were *Bacillus sp. Enterococcus faecalis and Klebsiella pneumoniae*, while the least encountered were *Proteus mirabilis, Pseudomonas aeruginosa* and *Salmonella sp.* (Table 1).

Eight fungal species (*Aspergillus niger, Aspergillus flavus*, *Aspergillus fumigatus, Aspergillus clavatus, Fusarium aqaeductuum, Mucor sp., Geotrichum candidum* and *Rhizopus stolonifer*) belonging to 5 genera (Aspergillus, Fusarium, Geotrichum, Mucor and Rhizopus) were isolated from all the 3 dump sites during the first week (Table 2). Some of the microorganisms observed in the first week of November were both Gram negative including *Escherichia, Klebsiella,* and Gram positive *Enterococcus* and *Bacillus*. After four weeks, mostly thermophilic microbes were isolated including *Bacillus subtilis* (Table 2). Only three of the bacterial species, (B. subtilis, E. coli and Salmonella) that were isolated in the 1st week, were also encountered in the 5th week (Table 3). With the exception of Staphylococcus oxidase, all the aeromycoflora were also isolated from the 3 dump sites (Table 4). Of the five genera of fungi, that were isolated in the first week, only one (Geotrichum) was not encountered in the fifth week (Table 3). The highest number of microbial colony forming units (9.0 CFU/ml) at the Ashaiman and Tema Community 1 dump sites on PDA medium, whereas the least (1.0 CFU/ml) was encountered at the same dump sites on Mc and PCA media (Table 5).

From the results, 2 (4.26%) *Staphylococcus aureus* were isolated from the waste scavengers prior to the start of work (control), while 12 (16.22%) isolated after scavenging. 16 (21.62) *Escherichia coli* were isolated from the scavengers while scavenging and 2 (4.62%) isolated before scavenging. Details of the organisms isolated are presented in Table 1.

Table 1. Microorganisms Isolated from Municipal Waste in the first week

	Microorganism	Media
Bacteria	*Bacillus sp.* Casimir Davaine[1,2,3]	Uri-Select
	Citrobacter freundi[1,2,3]	
	Enterobacter amnigenus Pfeiffer[1,2,3]	Plate Count Agar
	Enterococcus faecalis[1,2,3]	
	Escherichia coli Theodor von Escherich[1,2,3]	MacConkey
	Klebsiella pneumoniae Friedlander Uber[2]	
	Proteus mirabilis[3]	Salmonella-Shigella agar
	Pseudomonas aeruginosa[3]	
	Salmonella sp.[2,3]	
Fungi	*Aspergillus clavatus* deBary [1,2,3]	PDA
	Aspergillus flavus Link [1,2,3]	
	Aspergillus fumigatus Fres[1,2,3]	
	Aspergillus niger Van Tieghem[1,2,3]	
	Fusarium aqaeductuum [1,2,3]	
	Geotrichum candidum Victor Cardenes [1,2,3]	
	Mucor sp [1,2,3]	
	Rhizopus stolonifer (Ehrenb) Lind [1,2,3]	

Ashaiman dump site=1, Tema Community 1 dump site = 2, Kpone dump site =3

Table 2. Microorganisms Isolated from Municipal Waste in the 5th week

	Microorganism	Media
Bacteria	*Bacillus subtilis* Casimir Davaine[1,2,3]	MacConkey
	Escherichia coli Theodor von Escherich[1,2,3]	
	Salmonella sp. Theobald Smith[1,2,3]	Plate Count Agar
		Salmonella-Shigella agar
		Uri-Select
Fungi	*Aspergillus clavatus* deBary[1,2,3]	PDA
	Aspergillus flavus Link[1,2,3]	
	Aspergillus fumigatus Fres[1,2,3]	
	Aspergillus niger Van Tieghem[1,2,3]	
	Fusarium verticillioides[1,2,3]	
	Mucor sp. [1,2,3]	
	Penicillium Alexander Fleming	

Ashaiman dump site=1, Tema Community 1 dump site = 2, Kpone dump site =3

Table 3. Aeromycoflora at the Waste Dumping Sites in Tema Metropolis

	Microorganism	Media
Bacteria	*Bacillus sp.* Casimir Davaine [1,2,3]	Uri-Select
	Enterobacter amnigenus Pfeiffer[1,2,3]	Plate Count Agar
	Enterococcus faecalis[1,2,3]	MacConkey
	Klebsiella pneumoniae Friedlander Uber [2]	Salmonella-Shigella agar
	Proteus mirabilis[3]	
	Staphylococcus oxidase Rosenbach[2,3]	
Fungi	*Aspergillus clavatus* beBary[1,2,3]	
	Aspergillus flavus Link[1,2,3]	PDA
	Aspergillus fumigatus Fresenius[1,2,3]	
	Aspergillus niger Van Tieghem[1,2,3]	
	Fusarium [2,3]	

Ashaiman dump site=1, Tema Community 1 dump site = 2, Kpone dump site =3

Table 4. Mean Colony Forming Units (CFU/mL) of microorganisms Isolated from the Waste Dumping Site

Dumpsites	Dilution factor	PCA (37ºC)	Mc (37ºC)	Mc (44ºC)	PDA (37ºC)
	-1	3.90	3.70	3.30	2.92
Kp	-2	2.70	1.50	4.00	6.20
	-3	7.00	1.10	2.00	4.00
	-1	4.70	3.30	2.20	2.00
As	-2	1.20	4.00	8.00	4.00
	-3	7.00	1.00	1.00	9.00
	-1	7.90	8.90	5.50	2.50
TC1	-2	3.10	2.80	7.00	6.00
	-3	1.00	7.00	0.00	9.00
Total		1.22	2.52	6.00	7.39
Mean		1.36	2.81	6.66	8.21
SD		3.24	3.72	5.86	1.23

As = Ashaiman dump site, TC1= Tema Community 1 dumpsite, Kp = Kpone dumpsite

Table 5. Distribution of Microbial Isolates according to the number of scavengers per dumpsite

Microorganism	As (n=19)	TC1 (n=15)	Kp (n=40)	B (n=40)	Total
Bacillus sp.	4 (11.77)	3 (16.67)	2 (11.76)	1 (2.13)	10 (8.62)
Enterobacter amnigenus	7 (20.59)	5 (27.78)	1 (5.88)	0 (0)	13 (11.21)
Enterococcus faecalis	0 (0)	1 (5.56)	0 (0)	0 (0)	1 (0.86)
Escherichia coli	8 (23.53)	2 (11.11)	6 (35.29)	2 (4.26)	18 (15.52)
Klebsiella pneumoniae	5 (14.71)	2 (11.11)	1 (5.88)	1 (2.13)	9 (7.76)
Salmonella sp.	2 (5.89)	0 (0)	1 (5.88)	0 (0)	3 (2.59)
Staphylococcus aureaus	6 (17.65)	2 (11.11)	4 (23.53)	2 (4.26)	14 (12.07)
Staphylococcus epidermidis	2 (5.87)	3 (16.67)	2 (11.76)	41 (87.23)	48 (41.38)
Total	34 (100)	18 (100)	17 (100)	47 (100)	116 (100)

As = Ashaiman dump site, TC1= Tema Community 1 dumpsite, Kp = Kpone dumpsite, Values in parenthesis () represent percentages, B = Control subjects

Table 3 shows the distribution of microbial isolates from air propagules in and around the dump site. The result showed that the scavengers harboured similar organism that were found on the waste dumpsites and in the air. The organisms include *Bacillus subtillis*, *Staphylococcus aureus*, *Escherichia coli*, *Enterococcus faecalis, Salmonella sp.* and *Klebsiella pneumoniae*. Waste scavengers or rag pickers are those who forage the waste dumpsites searching for the hidden treasure in the waste. Apparently healthy young men are involved in this business which serves as a source of livelihood for them (Wachukwu et al., 2010). This type of occupation has its attendant problems, no matter how lucrative it may be. Ironically, they are not usually well protected and they go about without the appropriate protective clothes.

Every discarded clothes, aluminium, bottles or plastics are picked and sold to those who carry out small scale businesses, with just little payment. Similar views shared by Hayami et al. (2003) suggest that, these groups of people are faced with a lot of health hazards and challenges that they are not aware of. They are potential carriers of those pathogens that degrade the waste, which means they serve as vehicles for transmission of pathogens that are capable of causing diseases in the body.

The distribution of microorganisms was found to depend on the source of the swap when the result was subjected to a chi-square dependency test. The Pearson chi-square statistic and the p-values for the dependency of microorganisms on source of swap were 86.026 and 0.0000 respectively ($N = 116$, $df = 21$, $\alpha = 0.05$). The result suggests a very strong dependency at even 1% significance level since the p-value is less than the α-value of 0.05 or even 0.01 (for 1% significance level).

This means that the microorganisms isolated from the scavengers at the waste dump site were as a result of scavenging activities, and that of the control subjects also strongly depends on where they originated from. According to Table 5, the average number of microorganisms before scavenging, 5.875, was found to

be statistically the same as the average of 2.875 recorded after the scavenging.

The F-ratio and corresponding p-value were found to be 1.056 and 0.3123 respectively. With the p-value of 0.3123 being greater than the α-value of 0.05 (for 5% significance level), the result suggests no difference in the two mean. When the results were subjected to a One-Way Analysis of Variance (ANOVA), the number of bacteria identified from the various sources of swaps was found not to be significantly different at the level of the α, virtually the same statistically.

The mean registered number of microorganisms after and before scavenging was 4.250, 2.125, 2.250 and 5.875 respectively. The differences in these means were found to be statistically not significant as indicated in the f-ratio and its corresponding p-value of 0.474 and 0.7028 respectively. A pairing analysis of the these four sources of swaps also confirmed the result as none of the differences in mean of the various pairs was found to be significant when the Tukey differences in mean approach was used.

This study revealed that some of the microorganisms isolated from the waste dumpsites were also isolated from the scavengers, which confirm that they are indeed carriers of potential pathogens. For instance, *Salmonella* sp. that was isolated both from the dumpsites and waste scavengers are capable of causing typhoid fever and food poisoning. The bacterial species identified in the present study are almost similar to those reported earlier (Rahkonen *et al*., 1990; Crook *et al*., 1986; Rylander *et al*., 1964; Markanday *et al*., 2004). From the microbial study, it is evident that most of the bacteria, which commonly occur in the air and soil were opportunistic pathogens, which may cause infections.

Similarly, *Staphylococcus aureus* can cause food poisoning, wound infections, acute osteomyelitis in children and young adults. *Pseudomonas aeruginosa* can also cause wound and burns infections and are recalcitrant to treat with some antibiotics. The micro-organisms present in the air may cause infectious diseases in susceptible human beings. Scavengers may suffer eye irritation due to dust particles in the air and waste, or poisonous chemicals in the waste (Wachukwu *et al*., 2002).

The differences in the means of quantities of waste collected per scavengers of the three suburbs were found to be not significant at 5% significance level. According to the one-way ANOVA, the f-ratio and the corresponding p-value for the differences in mean of waste quantities generated by scavengers from the three suburbs were 2.344 and 0.1013 respectively. The result suggests that there is no significant difference in the mean quantity of waste collected by scavengers in Ashaiman, Kpone and Tema.

Interestingly, the bacterial organisms belonging to *Pseudomonas* spp. and the fungi belonging to *Rhizopus* spp. were found in the soil samples. Some of the micro-organisms identified in the air samples were also found in the soil samples and vice versa. The bacterial species identified in the present study are almost similar to those reported by Rahkonen *et al*. 1990; Crook *et al*. 1986; Rylander *et al*. 1964 and Markanday *et al*. 2004. From the microbial study, it is evident that most of the bacteria, which commonly occur in the air, soil, plants, food and water, were opportunistic pathogens, which may cause infections.

The most frequently isolated fungi in the present study belonged to the genus Aspergillus. This agrees with Sharma *et al*. (1997) who reported on an examination of soils from residential garbage of Bentul, India. In all the soil samples that were analysed, only two genera, namely, Aspergillus (190.9%) followed by Fusarium (118.18%) were most frequently isolated. Wienrich et al. (1999) also recommended A. fumigatus and A. niger as leading spores for the behaviour of the total concentration of fungi in the bio-waste due to their frequency of detection and seasonal dynamism. These two Aspergillus species were also encountered in the present study.

Aspergillus is well known for the spoilage of varieties of food materials. Kannan *et al*. (1994) has earlier mentioned that *Aspergillus* is known to produce aflatoxin a mycotoxin that is a toxic and carcinogenic metabolite produced by the genera. The high amount of aflatoxins present in contaminated food exerts their toxicological effect in animals and man. *Aspergillus fumigatus* is known to be associated with dust and its endotoxins are found in landfills and compost plants (Clark *et al*., 1983).

Mucor spp. was identified in and around the environment of Kpong and Ashaiman. It is the causal organism of fruit and vegetable rot, besides being responsible for mycoses of the lungs in human beings (Wachukwu *et al*., 2010). There could be potential risks to the environment and health due to the improper handling of solid wastes. The direct health risks concern mainly the workers on the field who need to be protected as far as possible from contact with wastes. For the general public, the main risk to health is indirect and arises from the breeding of disease vectors primarily flies and rats. The workers who handle refuse or who live near the disposal sites are infected with various pathogenic agents causing diseases (Kejding, 1964; Watt and Lindsay 1984).

The open dumping of garbage serves as a breeding ground for disease vectors such as flies, mosquitoes, cockroaches, rats and other pests. The high risk of spreading diseases like typhoid, cholera, dysentery, yellow fever, encephalitis, plague, malaria, and dengue fever through the vectors may not be ruled out. Particularly during the rainy season, the water run runoff and high humid conditions increase health hazards. The landfill sites, not properly maintained, are prone to groundwater contamination due to leachate percolation. Also, such waste is carried over long distances by stray animals like dogs, cows, *etc*., who spread the nuisance to a wider area (Markanday *et al*., 2004).

Another microorganism is *Escherichia coli*, which is one of the organisms that cause Urinary Tract Infection (UTI) and gastroenteritis in children. Also present in the waste dumps are the endospores forming bacteria such as *Bacillus* sp. These microorganisms produce spores and are commonly found in the soil. Therefore, they might easily get through to the scavengers when not well protected, and if they have any abrasion (i.e., cut) on the skin or leg, the tendency of these pathogens gaining entry into the body is obvious and the resultant effect will be infection, general body malaise and in some cases death. Wachukwu *et al*. (2010) and Chandramohan *et al*. (2009) share similar views.

Brooks *et al*. (2004) have also argued that the organic content of waste serves as nutrients for these organisms and waste containing some of these potential pathogens like *Salmonella.* sp., *Escherichia coli* or *Staphylococcus aureus* may contaminate underground water through seepage or contaminate municipal water supply through broken pipes, thereby, leading to epidemics of high proportion. Persons living within the vicinity of the waste dump could ingest the water and suffer from *Salmonellosis.*

The *Staphylococcus* spp. showed significant increase in the case of the scavengers. The *Staphylococcus* observed in this group of people may indicate the presence of bacterial infections, especially, with the *Staphylococcus aureus* which may result in skin injuries or disorders (Chessbrough, 2002). Staphylococcal disease of the skin usually results in a localized collection of pus, known as an abscess, boil, or furuncle. The affected area may be red, swollen, and painful. When *Staphylococcus* is in the blood (bacteraemia or sepsis) it can cause high fevers, chills, and low blood pressure. Mild skin lesions were observed among the waste scavengers, meaning that there might be allergic disorders and *Penicillium* infections. It can be inferred from this study that the activities of scavenging poses threat threat to the society considering the fact that they carry some of the microorganisms at the dumpsites on them, which are transported back into the society. One way of curbing the problem is to ensure the provision of basic protective clothing like hand gloves, safety boots, overalls, nose masks and other support structures, to protect them against the identified health hazards. Environmental education and enlightenment campaign will also help to curb the damage inherent in waste scavenging.

CONCLUSIONS

Waste scavenging among youth in the study area arises mainly due to poverty and the existence of waste dumps on one hand. Scavenging as an informal activity has also employed a number of youths in Tema metropolis. The average monthly income earned by a scavenger in Tema, was found to be above the minimum wage paid by Ghana government. Although children below the age of 10 working as scavengers can be seen as child labour, none were encountered in this study though poverty is what necessitates them to be engaged in.

The study revealed that recycling of waste materials in the Tema metropolis is low since there were a lot of waste materials left uncollected. The accumulation of textile and clinical wastes was negligible whereas the organic matter, metals, papers and plastics were considerable in the study area.

The study showed that microbial load at waste dumpsites poses a great threat not only to waste scavengers but to the society as well, as scavengers serve as routes for the transmission of certain pathogens associated with waste to the larger society, thereby, constituting some public health hazards. Therefore, it is evident from the present study that there are serious health hazards associated with scavenging in the Tema metropolis.

It is recommended that, waste recycling as a waste management option, although not new, should be introduced. The role of waste scavengers in this process has received little attention and this research has indicated that waste scavengers can easily be incorporated into the waste recycling process. In this way, the waste managers will be able to recover part of the costs of waste management. This research has revealed that scavengers have faced problems of informality and vulnerability to diseases and other health risks, hence the need for government's assistance.

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