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# Assessing the Awareness, Knowledge, Attitude and Practice of the Community towards Solid Waste Disposal and Identifying the Threats and Extent of Bacteria in the Solid Waste Disposal Sites in Morogoro Municipality in Tanzania

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**Abstract**
Solid wastes comprise all the wastes arising from human and animal activities that are normally solid, discarded as useless or unwanted materials. Health hazards associated with improper disposal of solid wastes to the community were investigated in Morogoro municipality. The aim of the project was to investigate the solid waste disposal practices and their health hazard implications to the community in Morogoro municipality. The study was conducted by considering several solid waste disposal sites based on three methods; observation, questionnaire survey and microbiological analysis. Based on observation method, several solid waste practices were detected including collection of wastes using trucks, wheel barrow, carriers made from elephant grasses and cement bags. Questionnaire survey pinpointed several diseases caused by solid wastes such as malaria, diarrhea, dysentery, cholera, typhoid and worm diseases from the respondents. From microbiological analysis, several pathogenic bacteria were identified from the solid disposal sites. The bacteria with their frequency of isolation identified were: *Salmonella typhimurium (16.7%), Shigella dysenteriae (16.7%), Citrobacter freundii (8.3%), Citrobacter amalonaticus (8.3%), Aerobacter aerogenes (8.3%), Proteus vulgaris (16.7%), Klebsiella oxyotoca (8.3%), Klebsiella (8.3%), E.coli (8.3%*). Solid waste generated by the daily activities of the people needs to be properly managed in such a way that it minimizes the risk to the environment and human health. Inadequate collection and disposal of solid waste is a major factor in the spread of disease and environmental degradation.
**Keywords:** Solid wastes, Dumpsites, Awareness, Health risks, Pathogenic bacteria, Waste management, Tanzania.

## 1. Introduction

Solid wastes comprise all the organic and inorganic waste materials that are normally non free flowing produced as a result of human and animal activities and have lost their value to the user, hence discarded as useless or unwanted. Discarding the waste generated by the daily activities is very important in order to minimize the risk to the environmental degradation, human and animal health (Mahar et al 2007). Inadequate collection and improper disposal of solid wastes facilitates multiplication of pathogens causing diseases like cholera and diarrhea and provides good breeding site for disease vectors like mosquitoes (malaria), flies (diarrhea) and rodents (Kassim and Ali 2006; Abul 2010). Dumpsites are good sources of environmental pollution (polluting soil, ground and surface water) due to the fact that they usually contain almost all types of pollutants from the initial collection sources (Kassenga and Mbuligwe 2009; Omofonmwan and Eseigbe 2009). Proper solid waste disposal is a big problem in urban cities and more so in developing countries. The intensity of the waste management problem increases with increased population due to the increased human activities and the solid wastes to be removed for disposal. Industries and urban management systems generate massive amount of solid wastes and most often dumping them in open fields posing a serious detrimental effects on the environment (Safiuddin et al 2010).

The main causes of improper solid waste disposal in urban centres are due to lack of good and enough infrastructures, non-implementation of existing environmental sanitation laws, irregular and unplanned dumping of solid wastes, population and urban growth due to rural-urban migration, insufficient capital to run solid waste management process and lack of new technology in waste disposing (Momodu 2011). The insufficient coverage of the collection system and methods, lack of institutional arrangement and information resources, inflexible work schedule, and insufficient information on quantity and composition of waste have been reported as the major problems facing the solid wastes management systems (Kyessi and Mwakalinga 2009; Ogwueleka 2009). Moreover, lack of awareness and active involvement of the households as the key stakeholders in service provision, delay of households to pay collection fees to the organizations concern with collection of wastes and

 

bad relationship between the households and the collectors of solid wastes are other factors hindering the process of proper solid wastes management (Kassim and Ali 2003; Kassim and Ali 2006).

In order to overcome the greatest problem facing many urban and semi-urban areas in many countries during solid waste management, several methods have been suggested including creation of special agencies for the collection, solid wastes incineration, recycling and conversion of Municipal Solid Waste (MSW) to wealth (Awopetu et al 2014; Oloruntade et al 2014). Also launching of an emergency city clean-up campaign, privatization of solid waste management services, and composting will ensure good management of solid wastes in the urban settings (Skat Foundation 2003). This should be accompanied with educating households, providing good services, creating good relationship with the households and collecting fees for the service at the light time (Kassim and Ali 2003).

The microbes that can be found in the solid wastes may range from bacteria, fungi, algae to protozoan whereby bacteria taking the lead. Bacteria play a great role in decomposing the solid wastes into simple and useful compounds important for soil heath and survival of plants when using them for their own metabolism (Vandevivere et al 2003; Zaved et al 2008). There are several pathogenic bacteria that have been reported to be found in the solid wastes including opportunistic and nosocomial bacteria. The list of opportunistic pathogenic bacteria include *Pseudomonas aeruginosa, Salmonella* spp.*, Klebsiella pneumoniae, Serratia marcescens, Acinetobacter baumannii, Staphylococcus aureus, Staphylococcus epidermidis, Enterococcus faecalis,* and *Streptococcus pyogenes*. While that of nosocomial pathogenic bacteria includes strains of *Escherichia coli, Staphylococcus aureus, Klebsiella pneumoniae, Lysinibacillus sphaericus, Proteus mirabilis* and *Serratia marcescens* (Hassen et al 2001; Zaved et al 2008; Hossain et al 2013; Saha and Santra 2014). Prompt removal and proper management (mechanical sorting and excavating) methods of solid wastes in the human residents may ensure public health from pathogenic agents at waste sites (Achudume and Olawale 2007).

The increases in population have created and exacerbated various environmental, health and other detrimental effects. This rapid increase in urbanization in Tanzania has overwhelmed local government's resources for provision of municipal solid waste management. Community participation in municipal solid waste management in Morogoro Municipality has not been effectively achieved. This is due to the lack of community empowerment and mobilization, organization, effective collection of local resources, outdated and poor reinforcement of environmental laws and lack of municipal authority commitment (Kalwani 2009). The solid wastes generated in Morogoro based on previous findings were reported to be 260 tons per day while only 26 tons of the wastes generated were collected (removed) per day (Kalwani 2009). The improper disposal of solid wastes in Morogoro Municipal can lead to occurrence of health hazards to the people living and or working near the disposal sites. There was a considerable public concern over the possible effects emanating from the improper disposal of solid wastes in the disposal site in Morogoro Municipality prior to this study. The aim of this study therefore, was to investigate the solid waste disposal practices and their associated health hazard implications to the community in Morogoro Municipality. Specifically we targeted to assess the awareness, knowledge, attitude and practice of the community towards solid waste management and identify the risks and problems associated with improper solid waste disposal to the community. The information obtained in this research will be useful to the municipal administration for proper planning and monitoring of waste disposal activities in the municipality. This in turn will reduce unnecessary health hazards such as bad smell and diseases emanating from improper waste disposal.

## 2. Materials and Methods

### *2.1 Study area*

This study was carried out in Morogoro municipality in Tanzania, lying between $6^{o}$ 35′S and $^{6}$o 57′S; and $37^{o}$ 33′E and $37^{o}$ 50′E at the base of the Uluguru Mountains. Morogoro municipal covers 260 square kilometres (100 sq mi) being bordered to the east and south by the Morogoro Rural District and to the north and west by Mvomero District. The municipal is under Morogoro region which is bordered by Coast region to the east, Dodoma and Iringa to the west, Ruvuma and Lind to the south and Tanga and Manyara to the north. Morogoro municipal constitutes 19 administrative wards and based on 2012 national census the total population was 315,866 whereby 151,700 were males and 164,166 females making an average household size of 4.1 (Kalwani 2009; National Bureau of Statistics 2013). The area is distinctly tropical and is characterized by high summer temperatures and low, but variable, rainfall between September and March. It is one of the hottest areas during the summer. This study included the following study areas; Kingo, Viwandani, Morogoro main market and Mawenzi market. All samples were transported to Sokoine University of Agriculture (SUA) at Microbiology laboratory in the Department of Veterinary Microbiology and Parasitology in Morogoro for further processing and analysis.

### *2.2 Research design*

Cross sectional study was employed for collecting information in the study area whereby the study areas were

 

visited once at a point in time.

*2.3 Sample collection and preparation*

Three samples (soil/humus) were collected from each main disposal site at different areas making a total of twelve samples. Each sample was collected in separate sterile screw cap tube, stored at 4ºC and labeled according to their source and location. Then all the samples were transported to the laboratory (SUA). In the laboratory, 10 grams of soil/humus were thoroughly mixed with 10 ml of sterile water. From the mixture above, 1ml aliquot volume was measured out and homogenized in a clean, dry sterile beaker containing 9 ml of distilled water giving a 1:10 dilution.

*2.4 Data collection*

Data were collected were based on three methods; observation (direct observation in study areas) structured questionnaires (gathered information from the respondent in the residents) and laboratory analysis of soil/humus samples collected in the disposal sites.

2.4.1 Observational method

Data were collected by observing how solid wastes were managed on the disposal sites. The observation were conducted throughout the municipal, by visiting four areas with disposal sites and taking a view of the whole process of collection services and general cleanliness of the municipal. This gave an opportunity to see the practices performed in management of solid wastes within households and dumpsites, collection activities, transfer stations and disposal site. The types of solid wastes disposed in the disposal sites were characterized based on nature, texture, odor, moisture and based on their originality.

2.4.2 Heading 3

Data were collected from residents who are closer and those are far from dump sites through structured questionnaire. The objective of the project was to obtain views and ideas of different people in Morogoro concerning the improper solid waste disposal. The following aspects were considered in the survey: collection methods of wastes, demand for service, awareness, payment for the service, satisfaction with the service, health effects observed due to improper disposal of wastes and the relationship of households with the solid waste collectors and stay duration of wastes in the disposal sites.

2.4.2 Laboratory analysis

The prepared samples were inoculated in blood agar and Mac Conkey through streaking technique. Inoculated plates were incubated aerobically and anaerobically at $37^0$C for 24 hours followed by isolation and sub-culturing. The pure colonies were macro- and microscopically examined and the observed features were recorded for identification. Biochemical tests of different sugars and reagents were performed to assist identification of enterobacteroceae from the pure colonies. The biochemical test performed includes IMViC, TSI test and other biochemical sugars and enzymes.

*2.5 Data analysis*

The data collected from questionnaire survey and laboratory works were analyzed using the computer software known as Statistical Package for Social Science (SPSS). From the SPSS Descriptive statistics (frequency and mean) were analyzed based on the microorganisms identified and frequencies of various isolates and data obtained from the questionnaire were developed. Descriptive statistics (mean and frequencies) were used to analyze the data obtained from the survey. Pie charts, bar graphs and tables, were also used to present the data.

## 3. Results

*3.1 Identification and characterization of solid wastes generated in Morogoro Municipality*

According to the observations conducted in different disposal sites found in the municipal including the households, Kingo, Mawenzi, Municipal market and Viwandani, solid wastes were identified and categorized based on their sources and biodegradability characteristics (Table 1).

 

**Table 1 Identification and characterization of solid wastes based on the source where the wastes were collected and biodegradability**

| Sources | Biodegradable wastes | Non-biodegradable wastes |
|---|---|---|
| Residential (single and multi-family homes) wastes | Food left overs, papers, bones, cardboards, pieces of clothes, leather, manures, charcoals, ashes, off use households equipment (such as chairs, tables, beds, filling cabinets, bags and bookcases). | Plastics of different types, empty bottles used for drinks, glasses, metals, radio batteries, off use households equipment (such as fridges, radios, televisions, bikes, kitchen stoves, lamps, plates, spoons, cups, filling cabinets, bags and bookcases). |
| Community Centers wastes | Food left overs, papers, bones, charcoals, pieces of clothes, pieces of woods, ashes, beddings and old bags | Scrap materials, plastics of different types, metals, batteries, off use electronics, and off specification products. |
| Market wastes | rotten fruits and vegetables of different types, coconuts, pieces of clothes, pieces of woods and boxes | Grasses of different types and forms, plastics of different types and metals |
| Street and roads wastes | Food left overs, papers, leather and pieces of clothes | Plastics of different types, glasses of different forms and types and metals |
| Commercial (Restaurants, offices, retail and whole sale) wastes | Food left overs, boxes, cardboards, papers, ashes, fabrics and leather left overs. | Car batteries and tires, oil bottles, plastics, construction and demolition materials, metals, glasses, metallic objects, drugs and chemicals, and electronics |

*3.2 Awareness, knowledge and practice of the community towards solid waste management*

The questionnaire survey used 80 respondents from respective households and 20 respondents from people doing their businesses close to the dumpsites in Morogoro municipality in Tanzania (n=100). The frequency distribution of education level of the respondents in the study area were as shown in Figure 1.

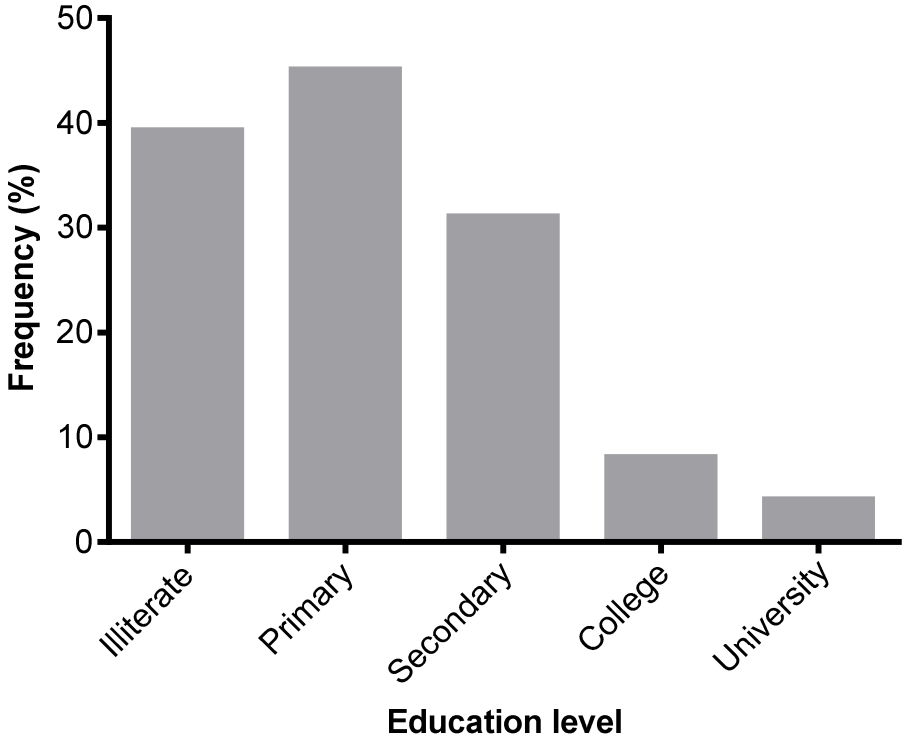


**Figure 1 The distribution of education background of the respondents (N=100) for questionnaire survey**

3.2.1 Collection and the flow of waste disposal in Morogoro Municipality

Residents provided their views on how they collected their home wastes and how the municipal collected wastes. The methods that were used by the respondents to manage wastes in their households included burning, packing

 

in different types of bags (cement bags, fertilizer bags and plastic bags famous as *Rambo*), collecting in dust bins, dump pits and municipal buckets (Table 2).

**Table 2 Collection methods of solid wastes used by respondents in the questionnaire survey in the study area (n=100)**

| Collection methods used | Frequency (%) |
|---|---|
| Burning (dry wastes) | 20 |
| Bags (cement and fertilizer used bags and plastic bags) | 30 |
| Dust bins | 15 |
| Dump pits | 22 |
| Municipal buckets (20 to 50 kg size) | 13 |

The solid wastes generated in Morogoro municipality can either come from residential premises (households), industries, markets, shops, offices (Government and private), and municipal areas (Figure 2). Solid wastes collected from the residential premises were either sent to the community collection centers (temporary dumpsites) or taken directly to the main disposal site (located in Viwandani area). The households accumulated solid wastes outside their houses in plastic bags (cement bags, fertilizer bags and small plastic bags famous locally as *Rambo*). The wastes were then collected by local governmental authorities or waste companies to the main disposal sites or by municipal workers to the community collection centers (example Kingo) using municipal wheel barrows. And for those households which were close to these dumpsites carried their wastes in plastic bags to the community collection sites. Wastes in community collection centers were taken to the main disposal sites by trucks in big municipal buckets. Normally, solid wastes from the households were removed twice a month although in some instances wastes stayed more than a month without being removed. Sixty two percent of the respondents were not satisfied with the way the wastes were removed from their houses due to delayed removal of the solid wastes. During taking the wastes to the trucks, some workers were seen carrying the bags with bare hands despite being given and told the importance of using protective gears.

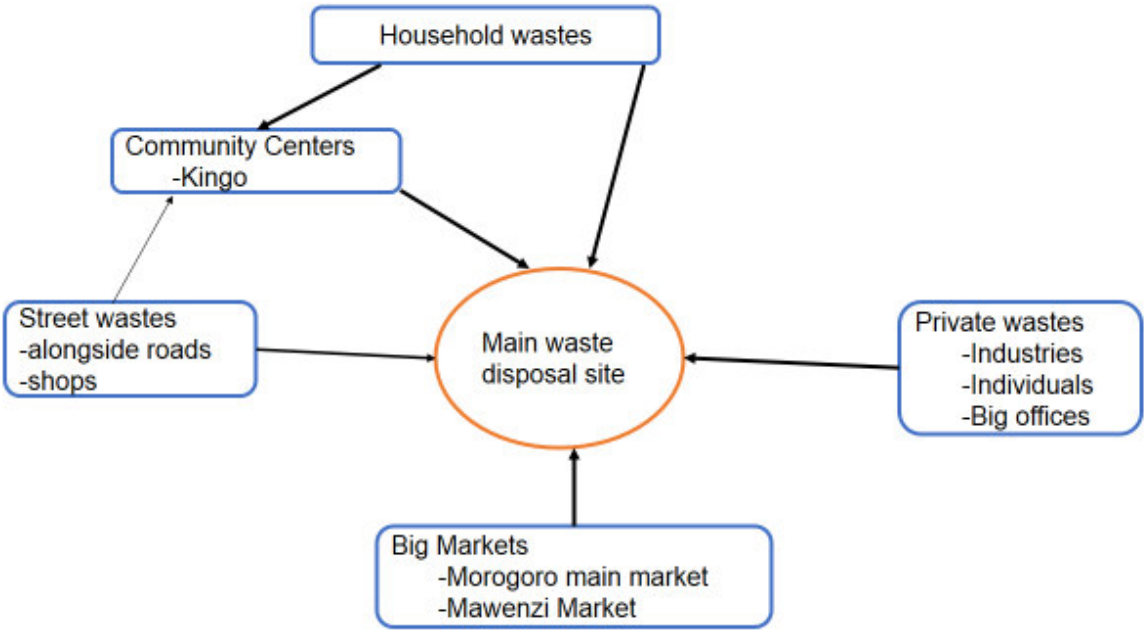


**Figure 2 The flow of collection of solid wastes in Morogoro municipality** (Arrows indicate the direction of collected wastes to the final destination)

In the main markets (Morogoro main market and Mawenzi market), a temporal collection site for solid wastes was set just besides the market. Mawenzi market highly known in Morogoro municipality for supplying fruits and vegetables, the rapidly decomposable solid wastes were found to be highly accumulated in the temporal disposal site. The collection of wastes in this temporal site was higher than the removal of the wastes due to insufficient of facilities for removing the wastes and high supply of the fruits in the market. The solid wastes from different parts of the market were collected by the municipal workers using wheel barrows to the temporal disposal site. This fruit market, the collection site produced bad smell most of the time due to fermented and

 

rotten fruits. During rainfall, the area was very wet, smelt badly and even there was flowing from the disposal site to the roads. Wastes from this market were taken to the main disposal site by trucks.

In Morogoro main market solid waste materials were collected from restaurants, business premises, and houses close to the market and from the market itself. The wastes were collected on the Western side of the Sokoine University of Agriculture Min-bus stand located on the Northern part of the main market. The main market and the stand are separated from each other by a small water sewage channel. In this temporal collection site, the wastes sometimes were put in the big municipal buckets and sometime the buckets were not there due to shortage of the buckets. Wastes from the market and those from private shops and restaurants were collected by the municipal workers and owners respectively. Then solid wastes were collected to the main disposal site by municipal trucks.

In Viwandani (industrial area), area composed of big industries in the municipal and it was the main municipal disposal site (Figure 2) where all the solid wastes of the municipality were disposed off. The community collected their wastes in plastic bags and sent them to temporal collection site before transporting them to the main disposal sites using trucks like in other temporal sites. People in this area faced problems of poor street roads for transporting wastes and bad smell from the main waste disposal site due to insufficient management of waste in the dumpsite. The municipal waste disposal site was found to be fenced and the guards were there at the main entrance to make sure that trucks were charged maintenance fee for disposal site.

Interviews from the community reported that, Kingo and Morogoro main market sites were better off than Mawenzi market and Viwandani temporal collection sites. Management of wastes at the sources especially the temporal disposal sites was performed by assigned workers for managing wastes. They used several equipment like shovels to shift and accumulate together the wastes. But in all areas we visited waste collection workers did not use protective gears, especially the important ones such as boots, gloves, overalls and masks.

3.2.2 Health effects caused by improper waste disposal

The participated residents gave their views on health effects that may be caused by the improper waste disposal to the community working and or living close to the disposal sites. The respondents suggested some of the diseases they thought could emanate as result of improper waste disposal. In this study the frequency for cholera was higher than the rest of the diseases reported by the respondent (Table 3).

**Table 3 Views of respondents on the possible diseases due to improper solid wastes disposal (n=100)**

| Disease | Frequency (%) |
|---|---|
| Malaria | 13 |
| Typhoid | 15 |
| Diarrhea | 26 |
| Cholera | 30 |
| Helminthosis | 6 |
| Dysentery | 10 |

Solid wastes were not managed properly many areas we visited from the households level to the main municipal disposal site. Majority of the people working or living close to waste disposal sites were not happy with bad smell coming from the sites and the disgusting appearance of the wastes in the disposal sites. Some of the indicators of improper solid waste disposal reported by the respondent included:

(a) An improperly collected and scattered wastes seen in the sites which often ended in blocking the drains or sewage canal during rainy season.

(b) Disposal sites acted as good breeding sites for flies as many flies were seen moving around the disposal sites during the day.

(c) Waste disposal sites like in Mawenzi market (fruits market) where the site was wet most of the acted as good source for mosquito breeding.

(d) Solid waste disposal sites have been reported to be shelters and source of food for rats.

(e) Improperly disposed wastes put the municipal environment in unattractive appearance.

(f) Respondents new that waste collection workers who did not use protective gears were at risk of occupational health hazards, including injuries from sharp objects which may results to cancer, tetanus and contracting diseases.

*3.3 Factors that lead to delayed and or improper waste disposal*

The residents who responded to the interview gave their views on awareness on the provision of the waste collection services. According to awareness of the service, 33% (n=100) of the residents said the service of wastes collection was provided by municipal council and it was free in charge while 67% said that the service was done by private companies and residents paid for the service, although environment clean-up was not

 

satisfactory. Sometime the service of collecting wastes delay for several days which makes wastes to decompose and produce bad smell. They delay was reported by private waste collection authorities to be contributed by some households delaying to pay the service fee. In the municipal community and market collection centers where wastes management was done by the municipal council, transport facilities to carry the wastes to the main disposal site were not sufficient.

*3.4 Isolation and identification of pathogenic bacteria*

Bacteria were identified from the samples based on the features observed on the culture medium, gram stain and biochemical test. Laboratory analysis identified six genera of bacteria: *Escherichia, Citrobacter, Klebsiella, Proteus, Aerobacter* and *Salmonella* in the different waste disposal sites in Morogoro Municipality. The morphological characteristics and biochemical profile of the isolated bacteria from the waste disposal areas are shown in Table 4.

**Table 4 Morphological and Biochemical characteristics of the isolates obtained from the solid waste disposal sites**

| Waste disposal site | Bacterial isolate | Cultural characteristics | Gram's stain reaction | Biochemical tests | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | CT | Urease | Oxidase | Indole | TSI ($H_2S$) | MR reaction | VP reaction |
| Morogoro main Market | *S. dysenteriae* | White mucoid colonies, NLF on MC | Gram – ve, rods | -ve | -ve | - | -ve | +ve | +ve | -ve |
| | *C. freundii* | White mucoid colonies, LF on MC | Gram – ve, rods | +ve | +ve | | -ve | +ve | +ve | -ve |
| | *K. oxytoca* | Mucoid, no haemolysis on BA, LF on MC, medium colonies | Gram – ve rods in singles | +ve | - | -ve | -ve | -ve, gas | -ve | +ve |
| Kingo | *C. amalonaticus* | White mucoid colonies, LF on MC | Gram – ve , rods | +ve | -ve | - | -ve | +ve, gas | +ve | -ve |
| | *A. aerogenes* | White mucoid colonies, LF on MC | Gram – ve , rods | +ve | - | - | - | +ve | - | - |
| | *P. vulgaris* | Swarming colonies and chocking smell on BA | Gram – ve rods in singles | - | +ve | -ve | -ve | +ve | +ve | - |
| Mawenzi Market | *P. vulgaris* | Swarming colonies and chocking smell on BA | Gram – ve rods in singles | - | +ve | -ve | -ve | +ve | +ve | - |
| | *S. typhimurium* | White mucoid colonies, NLF on MC | Gram – ve , rods | +ve | -ve | - | -ve | +ve, gas | +ve | -ve |
| Viwandani | *E. coli* | White on BA, smooth, non hemolyitic. LF on MC, medium colonies | Gram – ve rods in singles | -ve | - | -ve | +ve | -ve, gas | +ve | -ve |
| | *K. oxytoca* | Mucoid, no haemolysis on BA, LF on MC, medium colonies | Gram – ve rods in singles | +ve | - | -ve | -ve | -ve, gas | -ve | +ve |
| | *S. dysenteriaea* | White mucoid colonies, NLF on MC | Gram – ve, rods | -ve | -ve | - | -ve | +ve | +ve | -ve |

- = not applicable, +ve = Positive; -ve = Negative; BA = Blood Agar; CT=Citrate, TSI= Triple Sugar Iron, VP= Voges-Proskauer, MR= Methyl Red, MC=Mac Conkey , LF= Lactose Fermenter, NLF=Non Lactose Fermenter

The frequency of the isolates in the different wastes disposal areas in Morogoro are depictured in Figure 3. The highest frequencies of occurrence of the isolates were seen in the *Proteus* spp (18.7%), *Salmonella* spp (16.2%) and *Klebsiella* spp (13.4%).

 

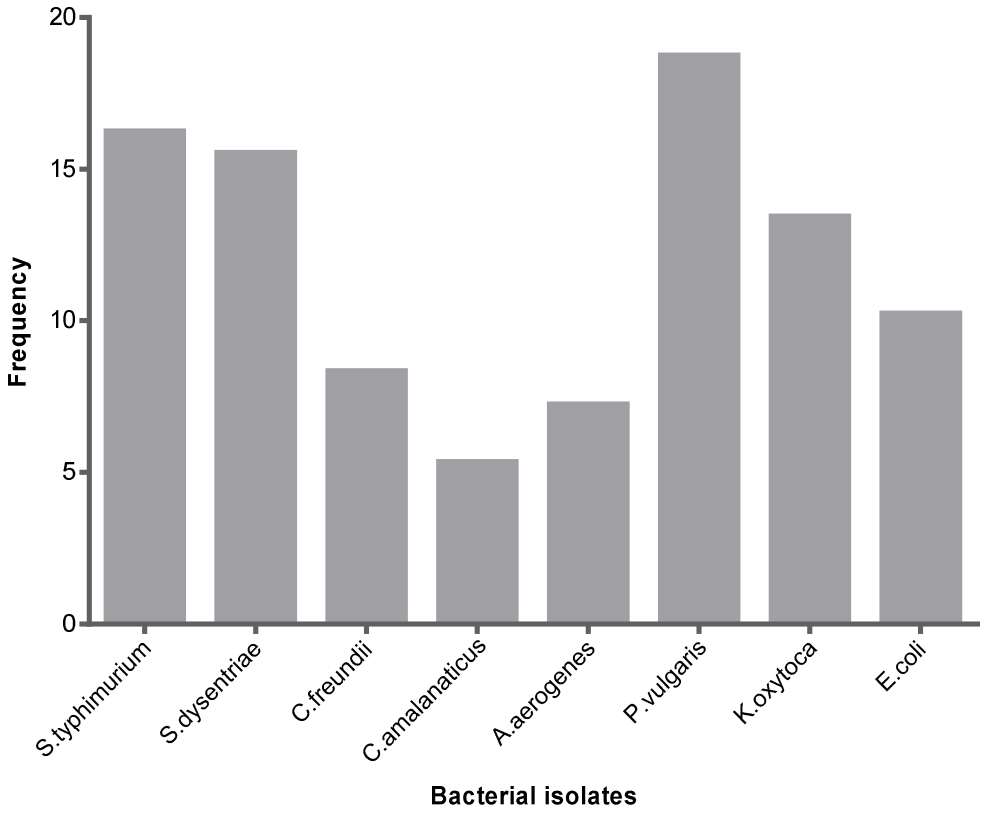


**Figure 3 Frequency of occurrence of bacterial isolates from the different waste disposal sites in the study sites.**

## 4. Discussion

*4.1 Awareness, knowledge and practice of the community towards solid waste management*

The solid wastes generated in Morogoro Municipality were classified into two main groups; the biodegradable (decomposed by microbes) and non-biodegradable solid wastes. The overall management process of the solid wastes collected in the Municipality was carried out by the Municipal Council. The other key stakeholders involved in the management of solid wastes included the households, private companies, local authority leaders and organizations. The level of education has shown to play a role at household level in solid waste management although it is not the only factor. Other factors that play a role based on previous studies includes one's socio-cultural factors particularly habits and customs operating in a legal framework and access to awareness trainings (Kalwani 2009). A good number of people in Morogoro Municipality did not participate in putting the environment clean due to perceived perception that it is the duty of the Municipal Council to put the municipal clean. In order to mitigate the indiscriminate waste dumping effective stakeholder relations is highly needed at every level of waste management (Achor et al 2014). The perceptions and attitudes are learned response and can therefore be modified or changed through education (George 2004). Formal education from different levels can help in understanding good waste management practices. Majority of women (who highly involved in day to day management of wastes) in Morogoro Municipality have been reported to be illiterates or have adult education which is probably due to the community settings and believes (Kalwani 2009). Some households threw their solid wastes in the waterways (canals and drains) especially during rainy season. This in turn blocked the waterways causing overflow of water (floods) and even damaging the road infrastructures and bringing problems to many people. Similar situation was observed and reported to be done by low-income families in Ghana (Boadi and Kuitunen 2004). This behavior can be changed if more efforts are directed towards mass health education campaigns on the harmful effects of indiscriminate disposal of wastes and the provision of adequate home collection services by both the public and private sectors (Modebe et al 2011).

The storage of solid wastes by the households in cement, fertilizer and plastic bags observed in this study was found to be similar in other African countries (Boadi et al 2005). However, the removal of the solid wastes from the households to the dumpsites involved payment for either facilitating the service or economic oriented service. This brought many challenges in managing the solid wastes generated. Some household delayed to pay the money (cost ranged from USD 1.5 to 3.0 per month) and some did not pay at all leading to

 

delay in removing the solid wastes in the residents. Political leaders in some areas influenced the household not to accept the private companies to collect the wastes by telling them that they would collect at lower price. However, they failed to collect the money from the household in time delaying the removal of the wastes from the households. Previous studies done to assess the households' willingness to pay to the solid waste collection and disposal services was significantly related to income and awareness of environmental quality (Dagnew et al 2012). The use of private sectors and community based waste management in waste collection and disposal have been recommended by many investigators in Tanzania (Kaseva and Mbuligwe 2005; Mgongolwa 2007) and other African countries (Akaateba and Yakubu 2013) to improve the management of solid wastes in municipals. However, full community participation in planning and execution of the privatization of the collection and disposal of solid wastes together with provision of waste management education is very important (Mungure 2008; Odufuwa et al 2012). In many municipalities in Tanzania suffers from the lack of a real plan for collection center locations and vehicle routes that leads to high consumption of municipal revenues (Lyeme 2011; Breeze 2012)

This study also revealed that, waste management service in both areas; in residents' households and municipal open areas in general to be not satisfactory. The reasons for this could be due to lack of motivation to environmental workers, inadequate manpower and financial support, inadequate collection methods, unwillingness of residents to pay for the services and lack of involvement of the private sector in waste management in some areas. The rapid growth of cities in Tanzania is overwhelming the resources generated, managerial and technical capacity. Furthermore, institutional weaknesses available in the Local Government Authorities contributed to poor service delivery including uncollected solid wastes in the households (Kyessi and Mwakalinga 2009; Breeze 2012; Lubuva 2012). The study by Kalwani (2009) pinpointed corruption as the main factor contributing to poor collection of resources in Morogoro municipal that could facilitate waste management.

The recommended methods for waste management include; collection and removal of solid wastes to the main disposal sites in time, recycling of solid wastes (use and reuse, converting the solid wastes to by-products such as energy source) and hierarchial integrated waste management (landfill, incineration, recycling and composting, use and reuse) (Nkwachukwu et al 2010; Bastani et al 2014). The methods that were found to be used in Morogoro Municipality included collection and removal of wastes to the main dumpsites, landfill, incineration and recycling. Recycling of solid wastes was done on plastic bottles only. Recycling of plastic bags and other non-degradable materials were not done. Total recycling of wastes has been recommended since it drastically reduces the emission of Greenhouse gases (GHG) and vapours that would otherwise have damaging effects on the environment (Eneh and Oluigbo 2012). Studies in Arusha (Tanzania) by Omari et al. (2014) on municipal solid waste management as a potential source of renewable energy, indicated the presence of a substantial energy potential to be recovered from degradable solid wastes (food, paper and wood waste). The paper recommends that waste recycling and composting activities be encouraged since this approach is considered to be the right measure in attaining sustainability in waste management (Kaseva and Mbuligwe 2005).

*4.2 Isolation and identification of pathogenic bacteria in solid wastes*

Findings from this study showed an existence of a good number of different bacteria species in the disposal sites (Municipal Market, Kingo, Mawenzi and Viwandani) in Morogoro Municipality. The bacteria isolated were; *Salmonella typhimurium*, *Shigella dysenteriae*, *Citrobacter freundii*, *Citrobacter amalonaticus*, *Aerobacter aerogenes*, *Proteus vulgaris*, *Klebsiella oxyotoca* and *Escherichia coli*. Previous studies identified several pathogenic bacteria in the disposal sites of solid wastes including *Bacillus substuilis*, *E. coli*, *Staphylococcus* spp., *Klebsiella* spp, *Pseudomones aeruginosa*, *Enterobacter* spp. *Acinetobacter* spp., *Enterococcus* spp., *Aeromonas* spp., *Salmonella* spp., *Streptococcus* spp., *Proteus mirabilis*, *Lysinibacillus sphaericus* and *Serratia* spp. (Adeyeba and Akinbo 2002; Achudume and Olawale 2007; Oviasogie et al 2010; Osunwoke and Kuforiji 2012; Hossain et al 2013). All these studies indicate the potential of solid wastes for harboring pathogenic microorganisms that may cause diseases to people living or working close to the disposal sites. The solid wastes dumpsites have enough nutrients to support large microbial populations.

The potential health implications of the isolated bacteria and other microorganisms in the solid wastes in the disposal sites are directed to the residents living or working close to the dumpsites. These residents are victims of parasitic (malaria, amoebiasis and helminthosis), respiratory (bronchitis and pneumonia), gastrointestinal (cholera, diarrhea and dysentery), genetic, dermatological diseases and eye infections (Cointreau 2006; Abul 2010; Osunwoke and Kuforiji 2012; Hossain et al 2013). Solid waste workers are at most likelihood of waste-related illnesses due to being continuously exposed to various health and safety risks ranging from musculoskeletal to dermal, to psychological for longer time (Rushbrook 2001; Bastani et al 2014). Other effects include production of leachates and gases when they are decomposing and are washed by percolating and infiltrating rain water into ground water (Omofonmwan and Eseigbe 2009; Omosowhofa et al 2014). Therefore, the health risks associated with the improper solid waste disposal should be taken into consideration when

 

planning location of the dumpsites. Temporal dumpsites located close to the community the wastes need to be removed early enough before the population of microorganisms goes to a significant level normally not more than two days.

## 5. Conclusion and Recommendations

Several modern methods for solid waste management has been well documented but all over the world from developed to developing countries still face great challenges in handling solid wastes. The rapid growth of cities and introduction of new technologies which generate new types of wastes poses great challenges in Morogoro Municipality. More efforts are needed by the Municipal Council to plan new strategies that will accommodate all stakeholders involved in waste management. These strategies should allow willingness to participate after extensive involvement from the initial stages of planning and providing knowledge and awareness of waste management. The health risks of improper waste disposal observed in this study and other studies can only be avoided if proper waste management is adhered to. The use of private sectors in waste management is very important to effectively manage solid wastes in Morogoro Municipality since it has been proven to work well in those areas which private sectors are in practice. Political leaders should not be the obstacles in implementing the use of private organizations but should play a role in educating the community to adopt it. The use of mass media (radios, televisions, newspapers, magazines) and teaching solid waste management in schools will facilitate the change of the attitudes, practice and perception of the community towards solid waste handling.

## 6. Authors' Contribution and Competing interests

AAC have made substantial contributions to conception and design of study, drafting and writing the manuscript and gave the final approval for the version to be published. BKL have made a contributions to acquisition of data, analysis and interpretation of results and proof read the manuscript. AM have been involved in drafting the manuscript and reading it critically and proof read the manuscript. All authors read and approved the final manuscript. The authors declare that they have no competing interests.

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