

¹Alban Chidiebere OGBONNA, ²Abubakar MIKAILU

THE ROLE OF THE INFORMAL SECTOR IN SUSTAINABLE MUNICIPAL SOLID WASTE MANAGEMENT: A CASE STUDY OF LAGOS STATE, NIGERIA

^{1,2}Department of Civil Engineering, Waziri Umaru Federal Polytechnic Birnin Kebbi, Birnin Kebbi, Kebbi State, NIGERIA

Abstract: The informal sector plays numerous roles in waste management in Nigeria and other developing countries. This research examined how informal sector players contribute to waste management, waste recycling and waste to wealth activities in Lagos State, Nigeria. Field observations, interviews and well-structured questionnaires were employed to collect data from participants of the informal sector in municipal waste managements in sixteen Local Government Areas (LGAs) of Lagos State, Nigeria. Landfills/dump sites within the studied Local Government Areas were visited in the course of this research. Data collected were analyzed and discussed. Scavengers at the dump sites and the residents around the dump sites were interviewed. The results/findings showed that waste collectors and scavengers earn income from waste management and they do not take safety measures into consideration in their waste collection, waste management and scavenging activities. The study recommends that the informal sector participants be recognized as stakeholders in the waste management since they contribute significantly to resource recovery and waste reduction. Government at all levels, professional bodies and relevant stake holders should organize regular enlightenment campaigns for the informal sector payers on the need to adhere to safety measures in the course of their activities.

Keywords: informal sector, resource recovery, scavenging, waste management, waste reduction

1. INTRODUCTION

Solid waste are all the wastes arising from human and animal activities that are normally solid and that are discarded as useless or unwanted. (Peavy et al 1985). The term solid waste as used in this research is all inclusive and it encompasses all sources (the heterogeneous mass of throwaways from residences, agricultural activities, commercial activities and industrial activities), all types (municipal wastes, industrial waste, and hazardous wastes) and their composition. According to Peavy et al (1985), wastes that pose a substantial danger immediately or over a period of time to human, plant or animal life are classified as hazardous wastes while industrial waste are those wastes arising from industrial activities and typically include rubbish, ashes, demolition and construction waste, special waste and hazardous wastes. Table 1 explains the classification of materials comprising municipal solid waste, and Table 2 reports the sources and types of solid wastes.

Table 1: Classification of materials comprising municipal solid waste. Source: Peavy et al (1985)

S/N	Component	Description
1	Food Waste	The animal, fruit, or vegetable (also called garbage) resulting from the handling, preparation, cooking, and eating of foods. Food wastes will decompose rapidly, especially in warm weather.
2	Rubbish	Combustible and non-combustible solid wastes, excluding food wastes and other decomposable materials. Typically combustible rubbish consists of materials such as paper, cardboard, plastics, textiles, rubber, leather, wood, furniture and garden trimmings. Noncombustible rubbish consist of items such as glass, crockery, tin cans, aluminum cans, ferrous and nonferrous metals, dirt and construction wastes.
3	Ashes and residues	Materials remaining from the burning of wood, coal, coke and other combustible wastes. Residues from power plants normally are not included in this category. Ashes and residues are normally composed of fine, powdery materials, cinders, clinkers, and small amounts of burned and partially burned materials.
4.	Demolition & construction wastes	Wastes from razed buildings and other structures are classified as demolition wastes. Waste from the construction remodeling and repairing of residential, commercial, and industrial buildings and similar structures are classified as construction wastes. These wastes may include dirt, stones, concrete, reinforcement steel bars, bricks, plaster, lumber, and shingles, plumbing, heating and electrical parts.
5.	Special wastes	Wastes such as street sweeping, roadside litter, catch-basin, debris, dead animals, and abandoned vehicles are classified as special wastes.
4.	Treatment plant wastes	The solid and semi-solid wastes from water, waste water and industrial waste facilities are included in this classification.

Table 2: General sources of municipal solid wastes. Source: Peavy et al (1985)

Source	Typical facilities, activities, or locations where waste are generated	Types of solid wastes
Residential	Single-family, and multi-family dwellings, low, medium and high rise apartments etc.	Food wastes, rubbish, ashes and special wastes.
Commercial	Stores, restaurants, markets, office buildings, motels, print shops, auto repair shops, medical facilities and institutions etc.	Food wastes, rubbish, ashes, demolition and construction waste, special waste, occasionally hazardous wastes.
Open Areas	Streets, alleys, parks, vacant lots, play grounds, beaches, high ways, recreational areas etc.	Special wastes, rubbish etc.
Treatment plant sites	Water, waste water, and industrial treatment processes etc.	Treatment plant wastes, principally composed of residual sludges

Lagos State is one of the densely populated and in industrialized cities in Nigeria. As a result the volume of waste being generated by this large population and industries is high and over whelming to all government agencies involved in the collection, transportation and disposal of municipal solid waste in Lagos State (Oyebode, 2013). The inability of

government owned agencies to adequately cope with the upsurge in the volume of municipal solid waste generated and its management led to the creation of vacuum in the collection, transportation, recovery, recycling and disposal of solid waste in Lagos State. The vacuum that was created by selective services and irregular management of solid waste was filled by both the formal and informal private sector in solid waste management (Adebola, 2006 and Karanja *et al*, 2013). The formal private sector is made up of registered waste collection, transportation and recycling companies with financial strength, some level of technical knowhow/experience in solid waste management and are generally mechanized. The informal private sector is made up of the cart pushers (The group involved in house to house waste collection, transportation and recovery), the scavengers (the group involved in the on-site waste recovery and scavenging), the resource merchants (the group involved in the purchase of the recovered recyclable and re-usable waste materials) and the recyclers (the group involved in the recycling of recovered waste materials to valuable materials and raw materials for the consumption of the industrial sector).

In Lagos State waste collection, transportation, recovery, recycling and disposal are mostly undertaken by the formal sector (the Lagos State Waste Management Authority and the registered Waste Management Companies/Contractors) and the informal sector players through the cart pushers, the scavengers, the resource merchants and the recyclers who make a living through their different roles in sustainable municipal waste management. The informal sector players collect different materials for their personal use and recover different materials to sell for reuse or recycling. They perform these activities without adhering to safety measures (Mohammad *et al*, 2015).

The scavengers play important roles in Lagos State management activities especially in terms of waste collection, transportation, reuse, recycling material recovery and disposal. According to Mohammad *et al* (2015), a significant value of the scavenged materials in contribution with waste minimization makes the scavenging not only an income opportunity for the poor but also an environmental friendly activities. Waste management in Lagos State has continued to create a lot of attention to the Government, researchers and the general public. The task of solid waste collection and disposal is far beyond the cost of municipal governments and the problem is likely to intensify unless alternative means to solving the problem are developed (Karanja *et al* (2013). Solid waste management is a complex task which depends upon, organization and cooperation between households, communities, private enterprises, professional bodies and Government agencies in providing technical solutions and regulations for waste collection, transfer, scavenging, recycling, and disposal. It is little acknowledged or even known that scavengers often contribute significantly to resource recovery and recycling of waste materials and can thus have a very positive impact on waste management systems (Haqueet *et al*, 2008).

Effective waste management, even when carried out informally can be an important facet of environmental protection and conservation (Karanja *et al* 2013). Supporting scavenging can result in grass root development, poverty alleviation and environmental protection (Mohammad *et al* 2015). Studies have found that when scavenging is supported, scavengers can earn higher income than unskilled workers. Besides, scavenging process will lead to less money and time spent on collection, transportation and disposal of waste (Wilson, *et al* 2006).

The aim of this research is to evaluate the role of the informal sector in municipal solid waste management in Lagos State, Nigeria. This paper examined the waste collection, transportation, recycling, scavenging, reuse and resource recovery activities carried out by cart pushers, scavengers, resource merchants, and other major players in the informal waste management in Lagos State. The research also examined the level of adherence to safety measures by the actors of the informal solid waste management in Lagos State.

2. METHODOLOGY

This research work is based on data collected from field observations, interviews and questionnaire administered to waste collectors, scavengers, waste cart pushers, resource merchants, recyclers and other Stockholders of the informal municipal solid waste management in sixteen Local Government Areas (LGAs) of Lagos State, Nigeria. Landfills/dump sites within the studied Local Government Areas were visited in the course of this research. Scavengers at the dump sites visited were interviewed and data collected were analyzed and discussed.

3. RESULTS AND DISCUSSION

— Demographic Characteristics of Respondents

Total number of respondents and their age

Table 3 shows the study area, the total number of people interviewed, and the number of questionnaires distributed within the selected Local Government Areas (LGAs) of Lagos State. It also shows the total number of respondents in each LGA. Figure 1 shows the age distribution of the respondents and it is observed that majority of the respondents aged below 50 years. This is the age bracket considered to be most productive in the society.

Education

It is important to evaluate the educational level of the actors of the informal sector in municipal solid waste management within the study area. From table 4 it is observed that only 55.6% of the respondents has acquired post primary education.

Table 3: Number of questionnaires distributed, and number of respondents

S/No	Local government areas (LGAs) studied	Number of Questionnaires distributed	Number of respondents
1	Alimosho	200	171
2	Kosofe	200	163
3.	Oshodi-Isolo	200	150
4.	Agege	200	187
5.	Amuwo-Odofin	200	173
6	Ajeromi-Ifelodun	200	131
7	Mushin	200	125
8	Ojo	200	118
9	Ikorodu	200	127
10	Surulere	200	134
11	Ifako-Ijaye	200	142
12	Shomolu	200	123
13	Lagos Mainland	200	119
14	Badagry	200	136
15	Lagos Island	200	147
16	Epe	200	150
	Total	3200	2296

This implies that most major players in the informal solid waste management do not know how harmful, unsafe and risky the waste collecting, scavenging, recycling and reusing may be and the need to employ safety measures in handling them. It is important to note that they do not observe safety measures in their activities and even after several years of waste picking they do not acquire any special skills and are hence unable to move into any other occupation. Trapped in the vicious cycle of poverty and debt they are forced to continue with waste picking as a source of livelihood and as a survival strategy. This is in agreement with the findings of Baud and Post (2003), Furedy (1992), Karanja, *et al*, (2013) and Wilson *et al*, (2006).

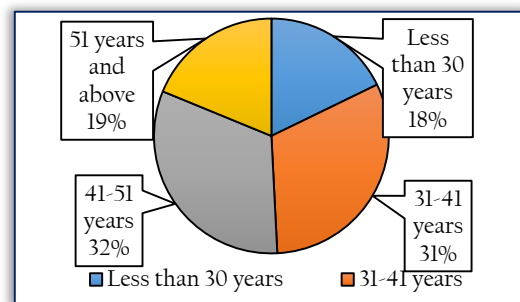


Figure 1: Distribution of the respondents by their Age categories

Table 4: Educational level of the respondents

Educational level	Frequency (f)	Percentage (%)
Less than primary education	372	16.2
Primary education	648	28.2
Secondary education	657	28.6
Tertiary education	619	27.0
Total	2296	100

— Types of Waste

The livelihood of the urban individual actors and the income derived from waste management is partly determined by the type of waste that the individual actors are engaged in. This is because the type of waste that is collected by the waste workers had an attached economic and social value and therefore will determine the profitability of the end product (Karanja *et al*, 2013, Baud and Post, 2003, Mwangi, 2000, and Oyeboode, 2013).

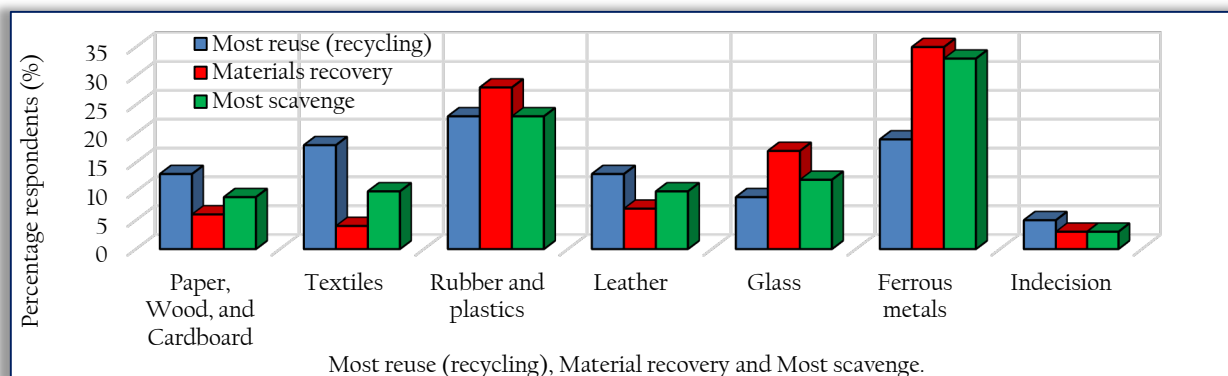


Figure 2: Most reuse (recycling), material recovery and most scavenge materials

From Figure 2, field observations and interviews ferrous metals, plastics, rubbers, textiles, leathers, demolition and construction wastes, paper, cardboard, wood, furniture, glass, tin cans and aluminum cans were mainly the categories of wastes collected, recycled, and scavenged by individual actors. Ferrous metals, construction and demolition wastes, plastics, rubber, and cans were greatly preferred by the individual actors partly because that are readily available and secondly they have immediate reuse which makes them easy to sell. They are also recyclable which makes the valuable

and a higher source of income compare to other categories of wastes. Most of the respondents earn income by transporting the waste to dump sites. This concurs with the findings of Hague *et al*, (2008), Mohammad *et al*, (2015), and Oyebode, (2013).

— Income Generated From Informal Solid Waste Management Activities

Income influences the socio-economic status of individual actors in the society and also determines the sustainability of livelihoods in the community (Baud and Post 2003, Oyebode, 2013, and Mwangi 2000). Table 5 shows that the informal sector players in municipal solid waste management earn living from their role in municipal solid waste management. It can be observed that informal sector players earn a living through municipal solid waste management.

Table 5: Respondents income per month from municipal solid waste management

Respondents income per month (Naira)	Frequency (f)	Percentage (%)
Below 10,000	299	13.0
10,001 – 50,000	351	15.3
50,001 – 100,000	597	26.0
100,001 – 150,000	560	24.4
150,000 and above	489	21.3
Total	2296	100

Note: N370.00 = 1.00 US Dollar as at the time of this research.

— Most reused, most recycled and most scavenged materials

Figure 3 shows the percentage respondents to most reuse (recycling), material recovery and scavenge waste material within the studied area. It can be observed from Figure 3 that Paper, wood, cardboards, plastics, leather, rubber and plastics, glass, textiles and ferrous metals are the principal recoverable materials, reusable (recyclable) materials and scavenged materials contained in municipal solid wastes. In any given situation, the decision to recover any of or all these materials is usually based on an economic evaluation and on local considerations. Reuse (recycling) of waste materials now occurs commonly in those situations where a product has utility in more than one application.

Most recycled leather is a composite of shredded leather scraps and residues collected from tanneries and other leather product manufacturers. The shreds are treated with resin, glued together and then shaped into, say, part of a wallet or seat cover. The finished recycled leather product will have the look and feel of new, non-recycled leather. In general, recycled leather is less expensive than its traditional counterpart. Textile recycling is the process by which old clothing and other textiles are recovered for reuse or material recovery. It is the basis for the textile recycling industry. Glass bottles and jars are 100% recyclable and can be recycled endlessly without any loss in purity or quality. Glass is taken from the bin and taken to a glass treatment plant. The glass is sorted by colour and washed to remove any impurities. The glass is then crushed and melted, then moulded into new products such as bottles and jars. Glass does not degrade through the recycling process, so it can be recycled again and again. Ferrous metals are mainly composed of iron and have magnetic properties. Steel, an iron alloy containing carbon, is by far the most-recycled material in the world. The use of scrap metal has become an integral part of the modern steelmaking industry, improving the industry's economic viability and reducing environmental impact. Compared to ore extraction, the use of secondary ferrous metals significantly reduces CO₂ emissions, energy and water consumption and air pollution. At the same time, the recycling of steel makes more efficient use of the earth's natural resources.

— Occupational Health Hazards and Associated Risks

This research identifies several health problems which are common to most waste management processes. Though all are not strictly health related problems, they are of less important, especially when health is seen as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Odour is unlikely to present a health hazard, but it may influence the local community's perception of the risks and lead to stress which is an occupational health hazard. Gaseous emissions or smoke fumes are known to have putative effects on human beings and many lead to congenital malformations at birth (Karanjaet *al* 2013 and Mwangi, 2000). Figure 3 shows the respondents' perceptions on whether they interact with hazardous waste materials in the process of municipal solid waste management.

In order to establish whether the respondents working in solid waste management were working in health risk environments, a set of the possible health effects of working in the sector were listed and the respondent were requested to list the ones that affects them. Their response were tabulated in Table 6 which shows that smoke fumes and odour, back aches and headaches, dust and cough, and cuts were the highest cause of health hazards. This is partly because they cut across all the solid waste materials under investigation in this research. It is important to note that in all the categories except the eye problem health hazard, the responses were very high and therefore it is evident that the individual actors in informal solid waste management work in risky environment.

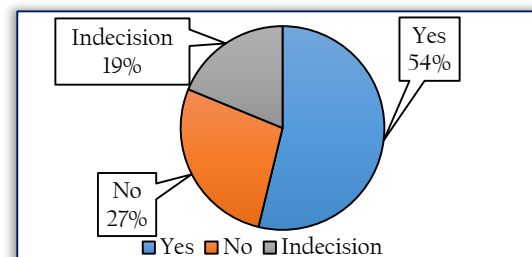


Figure 3: Respondents' perceptions on whether they interact with hazardous waste material

Table 6: Health risk encountered by respondents

Health risk Respond	Cuts		Skin disease		Dust and cough		Smoke, fumes and odour		Back pains		Eye problems	
	f	%	f	%	f	%	f	%	f	%	f	%
Yes	1607	70.0	1899	82.7	1860	81	2011	87.6	1855	80.6	1685	73.4
No	689	30.0	397	17.3	436	19	285	12.4	441	19.4	611	26.6
Total	2296	100	2296	100	2296	100	2296	100	2296	100	2296	100

From table 6, most respondents encountered different categories of health risk from municipal solid waste. This indicates that majority of the actors in solid waste management in selected Local Government Areas (LGAs) within Lagos State in an attempt to attain livelihood work in condition that subject them to high risks which are detrimental to their health. These findings concur with *Karanjaet al (2013)*, they concluded that the actors of solid waste management oblivious of their working condition and in search of livelihood end up working in deleterious conditions which are characterized by cuts, smoke fumes, bad odour, back aches and headaches. Therefore the sector needs to be regulated by the municipal authorities to ensure a conducive working environment. These findings also concur with the study were the researchers concluded that most informal sector actors do not take any health precaution measures while undertaking their duties which constitute real safety hazards, the urban poor cannot afford adequate protective clothing or equipment and often for purposes of speed, do not want to use them (*Baud and Post 2003, Oyeboode, 2013, Mohammad et al, 2015, Oyeboode, 2013, Wilson et al, 2006, and Mwangi 2000*).

Research visit to selected dump sites/landfills within Lagos State reveal that waste deposits at the dump site comprises of a mixture of municipal waste, hazardous wastes, hospital waste and industrial waste which pose severe health risk to scavengers and other players in solid waste management. Indiscriminate dumping of municipal waste in open spaces, road medians etc. and handling municipal waste without strict adherence to safety measures give rise to numerous potential health risks to the environment and to human health.

The direct health risks are associated with those working in the field with little or no compliance to safety measures. For the public the main risks to health are indirect and related to poor and contaminated water, land and atmospheric air. In addition temporary dump sites and most waste collection points provide attractive breeding ground for flies, rats, mosquito etc. In an attempt to discover some valuable, recyclable and marketable items, scavenger and waste collectors rummage through putrefying waste heaps including hazardous, toxic and hospital waste using their bare hands and feet, hence they come in direct contact with infectious waste materials. This makes them highly susceptible to a number of health hazards. It is therefore evident from the findings of this study that most scavengers and waste collectors work in hazardous conditions and once in a while receive cutting from broken metals and glasses. This is in agreement with the study conducted by *Furedy (1992), Mwangi (2000), Zamberia, (2006): and Oyeboode, (2013)*.

— Safety Measures

According to *Karanjaet al (2013)*, empowerment means enhancing an individual capacity to make choices and translate these choices into preferred actions and outcomes. The transformation of these choices into the desired actions is influenced by the factors and the opportunities available. This research has established that the role of the informal sector in municipal solid waste management process exposes the individual actors to risky and hazardous environment. Therefore the actors in the sector need to be enlightened and empowered to make rational decisions and take precautionary measures. Table 7 shows that majority of those working in the sector do not adhere to safety measures and do not use safety wears and garments. This shows that scavengers and all informal sector players in municipal solid waste management activities are not enlightened on the need to adhere to safety measures and the risk their activities pose to their health irrespective of the income they make from their roles in municipal solid waste management.

Table 7: Percentage adherence to safety measures by respondents

Safety measures	Safety eye wears (%)	Hand gloves (%)	Safety garments/ gowns and rain coats (%)	Safety boots and rain boots (%)	Safety nose cover (%)	Helmet (%)
Yes	19	23.4	5.3	31.8	11	3.1
No	81	76.6	94.7	68.2	89	96.9
Total	100	100	100	100	100	100

4. CONCLUSION AND RECOMMENDATIONS

In conclusion, the results show that the strategies employed by actors in solid waste management have an outcome on their livelihoods. The strategies used are dependent on the availability of the waste materials and the value attached to waste end product. Reuse of waste has greater recovery potentials and reduces substantially the amount of waste to be disposed. Recycling as a waste management strategies provides employments opportunities and with the increasing cost of raw materials, recycling provides a cheaper source of raw materials for manufacturing industries.

Field visits to selected dump sites/landfills and the interviews conducted at the dump sites established that there are intense scavenging for recyclable and reusable waste at the dump sites. Search for valuables, recyclables and reusable at dump sites has always been driven by poverty and desire to earn a living, but the emergence of recycling industries and waste resource merchants have enhanced the search for recyclable, and reusable materials in the dump sites as a ready

market for the materials exists, making it a popular municipal waste management strategy for the informal sector in Lagos State Nigeria and thereby contribute significantly in reducing the waste that is scattered all over Lagos State.

The study also concludes that the actors of the informal sector in municipal waste management have been working in conditions that put their health, which is an important asset to them at risk for not undertaking safety preventions. This research also concludes that in spite of scavenging provides a means of livelihoods to major players in the informal solid waste management in Lagos State, it also substantially reduces the final waste that needs to be disposed in the dump sites. This constitutes both financial and environmental benefits.

The following recommendations were made at the end of this study.

- # This research work established that there is a ready and profitable market for reusable and recyclable municipal waste materials in Lagos State, Nigeria. Therefore there is an urgent need for Lagos State Government to create a sustainable environment and legislation of the informal sector participation in municipal solid waste management. There is also need for the Lagos State Government and the bank of industry to grant soft loans to waste recycling industries operating in Lagos State.
- # Government should harness the abundant manpower of the cart pushers, scavengers, the waste resource merchants, the recyclers and all actors of the informal sector in waste management by advocating and enforcing the use and application of safety measurement in their activities. This will make the working environment safer and encouraging for the participation of youth thereby creating employment.
- # The role of the informal sector in municipal solid waste management and in the reduction of waste in dump sites should and must be captured in the analysis, planning, design, implementation, monitoring and evaluation of sustainable municipal solid waste management in Lagos State, Nigeria.
- # This research found out that the activities of the informal sectors in municipal solid waste management pose great occupational health risks and hazards to them. Therefore efforts should be made to encourage them to undergo routine medical checkup at affordable price.
- # Further research on the impact of municipal solid waste management on the health of the informal sector players should be conducted as a case study to establish its effort on the healthy life of an individual actor and to establish the major ailments encountered by the individual actors as a result of their roles in the municipal solid waste management.
- # The research also recommends the urgent need to carry out an investigation into the extent of pollution of ground water within the vicinities of the municipal solid waste dump sites to safeguard the lives of the residents of the municipality particularly those who live within the vicinities of the dump sites.
- # Lagos State Government and the National Orientation Agency in partnership with the relevant professional bodies should organize regular enlightenment campaigns for the informal sector players on the need to adhere to safety measures in the course of their activities.

References

- [1] Adebola O.O (2006): "The Roles of Informal Private Sector in Integrated Solid Waste Management in the achievement of Millennium Development Goal (MDGs) in Lagos, Nigeria". A Paper presented at the Solid Waste, Health and Millennium Development Goals, CWG-WASH Workshop, Kolkata, India.
- [2] Baud I.S.A and Post, J. (2003): "Between Markets and Partnerships: Urban Solid Waste Managements and Contributions to Sustainable Development". *Global Built Environment Review*, Vol. 3(1) Pp. 46–55.
- [3] Furedy, C. (1992): "Garbage: Exploring the Options in Asian Cities". *Environment and Urbanization*, Vol. 4 (2) Pp.42 –61.
- [4] Haque, A. Mujtaba I.M., and Bell J.N.B (2008): "A Simple Model for Complex Waste Recycling Scenarios in Developing Economics". *Waste Management*, Vol. 20 (8), Pp 625 –631.
- [5] Karanja S.N *et al* (2013): "Influence of Informal Solid Waste Management on livelihoods of Urban Solid Waste Collectors: A Case Study of Nakuru Municipality, Kenya". *International Journal of Humanities and Social Science*, Vol. 3 (13), Pp. 95 –108.
- [6] Mohammad A, Kenneth M.P, and Emad S. (2015): "The Role of Informal Sector in Waste Management, A Case Study of Tafila– Jordan". *Resources and Environment*, Vol. 5 (1), Pp 9 –14.
- [7] Mwangi, S.W. (2000): "Partnership in Urban Environmental Management: An Approach to Solving Environmental Problems in Nakuru, Kenya". *Environment and Urbanization*, Vol. 12 (2), Pp. 77 – 92.
- [8] Obirih – Opareh, N. (2002): "Solid Waste Management in Acera. The Impact of Decentralization and Privatization on the Practice and Performance of Service Delivery". *Universitat Van Amsterdam, AGIDS, Netherlands*.
- [9] Oyeboode,O.J. (2013): "Solid Waste Management for Sustainable Development and Public Health: A Case Study of Lagos State in Nigeria". *Universal Journal of Public Health*, Vol. 1(3) Pp.33–39.
- [10] Peavy H.S., Rowe, D.R. and George, T. (1985): "Environmental Engineering". 1st Edition, Mc Graw – Hill Book Co. Singapore and Urban Development Policy". Working Paper 225. Overseas Development Institute, London UK.
- [11] Wilson, D. C., Velis C., and Cheeseman C. (2006): "Role of Informal Sector Recycling in Waste Management in Developing Countries. *Habitat International*, Vol. 30 (14): Pp. 797 –8–8.
- [12] Zamberia, C.I (2006): "Opportunities and Challenges in Privatizing Urban Environmental Infrastructure: Lessons from the Dandora Dump Site Nairobi". University of Johannesburg.

ISSN 1584 - 2665 (printed version); ISSN 2601 - 2332 (online); ISSN-L 1584 - 2665

copyright © University POLITEHNICA Timisoara, Faculty of Engineering Hunedoara,
5, Revolutiei, 331128, Hunedoara, ROMANIA

<http://annals.fih.upt.ro>