MUNICIPAL SOLID WASTE COLLECTION AND MANAGEMENT STRATEGIES IN AKURE, SOUTH-WESTERN NIGERIA

[1] A.J. Oloruntade, [2*]P.A. Adeoye, [3]F. Alao

[1]Department of Agricultural Engineering Technology
Rufus Giwa Polytechnic, Owo, Ondo, State NIGERIA

[2]Department of Agricultural and Bioresources Engineering
Federal University of Technology, Minna, Niger State, NIGERIA

[3]Department of Agricultural Engineering
Federal University of Technology, Akure, Ondo State, NIGERIA

ABSTRACT

Municipal Solid Waste Management (MSWM) has become one of the greatest problems facing many urban and semi-urban centres of Nigeria. This study presents the various steps and approaches taken in Akure, Southwestern Nigeria, to combat the menace. Such approaches included creation of special agencies for the collection, recycling and conversion of Municipal Solid Waste (MSW) into useful products. Also, recruitment of Sanitary Inspectors and Volunteer Youth Corps, awareness campaigns and collaboration with other government agencies has improved compliance with sanitary laws, thus helping in effective MSWM and making the city appear neater and the environment is more habitable. The study, therefore, suggested the need for MSWM cost sharing between the government and the people, strengthening of all enabling sanitary laws and adequate budgetary allocation for all concerned agencies, involvement of Private Sector Participation (PSP) and awareness campaigns to sustain the present level of MSWM efforts and increase the tempo to guard against future population increase.

Keywords: environment, management, Sanitary Inspectors, solid waste, waste recycling

INTRODUCTION

Municipal Solid Waste Management (MSWM) has continued to be a major problem in many developing nations of the world. The Management of Solid waste has gradually become a threat to the environment of developing countries as these nations are progressively moving towards industrialization (Awomeso et al. 2010). Geoffrey, (2005) reported that solid wastes of the different categories being generated, had posed a serious problem for various solid waste management systems in Nigeria. The MSWM has become one of the most serious environmental challenges facing many cities in the Nigeria. Ugwuh, (2009) observed that in many cities in Nigeria, MSWM is a serious problem, this is in view of the tremendous increase in the volume of wastes generated daily in the country. Population increase, rapid urbanization, industrialization and economic growth are many of the reasons for the increased MSW generation. An average Nigerian is esti-

mated to generate about 0.49 kg of solid waste per day with households and commercial centres contributing almost 90% of total urban waste burden (Ogwueleka, 2009). Existing information on industrial, agricultural and biomedical waste profiles in Nigeria is still little. Recently there has been a marked increase in the amount of plastic wastes generated in Nigeria, as it is the case with most developing countries; a greater percentage of MSW is composed of organic (putrescible) matter. A typical solid waste management system in developing countries displays an array of problems, including low collection coverage and irregular collection services, crude open dumping and burning without air and water pollution control, the breeding of flies and vermin, and the handling and control of informal waste picking or scavenging activities (Chen, *et al.* 2010, Manaf, *et al.* 2009). As urbanization and industrialization continue to take place, the management of solid waste is becoming a major environmental and public health problem in urban areas. These problems are caused by technical, financial, institutional, economic, and social factors which constrain the development of effective solid waste management systems (Turan, *et al.*2009).

It is a generally accepted view that many urban cities in Nigeria lack effective MSWM strategies. However, the situation varies from city to city and the way one government is handling the MSW menace is different from other (Imam *et al.* 2008). In Akure the Ondo State capital, a lot of efforts have been geared towards effective MSWM to make the city aesthetically pleasing and environmentally friendly, realizing the importance of the city as a state capital and appreciating the recent rural-urban migration being witnessed. Also coupled with the increased economic activities and social status of the inhabitants of the city, successive governments in the state have taken seriously the issue of MSWM. Ondo state government has performed creditably well in MSWM. The achievement in Ondo state can be compared favourably well to that of Lagos state which has become a model for the whole Nigeria in respect of MSWM. This paper is therefore intended to highlight the approaches of the state and local governments to MSWM in Akure with a view to making many other urban cities to take a cue from such rewarding efforts.

The Study Area

Akure (Figure 1), the study area is a medium-sized urban centre and became the provincial headquarters of Ondo province in 1939. In 1976, it became the capital city of Ondo State and a local government headquarters. The state has eighteen (18) local government areas and a land area of 13,595km^2. Akure is located on Latitude 7^0 15^1 North and Longitude 5^0 15^1 East. The state lies entirely within the sub-humid tropics (Olanrewaju, 2009). In recent time, population of Akure has witness a sharp increase, the increase may be attributed to the fact that Akure is the Ondo State administrative headquarter and also the capital city of Akure Local Government area. Since the rebirth of democracy in Nigeria in 1999, Akure has continued to witness tremendous increase in population as a result of rural-urban migration arising from the influx of many political office holders and their families as well as job seekers. While the 1991 census put the population of Akure at 324,000, the current population of the city is put at 495,000. By 2015, it is projected that Akure will be inhabited by about 1.8 million people (NPC, 2009).

FIGURE 1
Map of Nigeria Showing the Position of Akure. (Olanrewaju, 2009)

METHODOLOGY

This paper is a review work. It assesses the present happenings in respect of MSWM in Akure with a view to comparing it to what has happened in the past. The comparison would be used to project into future municipal waste generation to be able to suggest a pro-active plan to tackle the menace of municipal wastes. To achieve this, various waste management agencies in Akure were visited. Their operations were evaluated with respect to the available equipment and personnel. Information on trends in municipal waste generation in Akure, collection, management and disposal was also sought for from them. People living in the town were also interviewed to know if the approaches to MSWM of these agencies are having any positive effect on them.

Sources and Nature of MSW Generated in Akure

Before Akure was made the state capital, the inhabitants were predominantly farmers. However, the presence of Government agencies when the city was made the capital of Ondo state changes the status of people in the town to government workers, business men and artisans. The occupation, social status and higher income level of the inhabitants therefore came with its attendant effect of more MSW generation. Imam et al. (2008) stated that population, level of industrialization, socio-economic status of the citizens and the kinds of commercial activities being predominant in various states of Nigeria determine the quantity and rate of solid waste generation. More waste is generated from homes, market places and small and medium scale industries in the town. Hence, its initial MSW hitherto dominated by agricultural wastes has been changed. The city as shown in Figure 2, now produces MSW ranging in characteristics from organic to inorganic, industrial wastes, plastics, glasses, wood and paper.

The composition of wastes also varies based on social status of the citizen. The composition of collected wastes in high income, low income and middle income areas of the city shown in Table 1 are not the same, Institutional wastes and industrial wastes also vary in composition and properties.

Quantitatively, MSW generated in municipality alone based on 0.32kg/cap/day in 2005 was estimated by Olanrewaju, (2009) as about 180,000 metric tons/year. In Akure, increase in salaries of workers in recent times has increased the individual income of households making more varieties of assorted drinks and foods affordable. Increased individual households incomes have also led to frequent throwing up of parties in a manner that is a wide departure from the traditional restriction of such to the dry seasons. As a result of this, naming, birthday, and funeral ceremonies and political party programmes/gatherings are held throughout the year. In many of these parties, foods are served in disposable plates, drinks in cans, plastics and bottles, thus leaving behind at such venues litters of plastics containers, cans, foil papers and bottles.

Furthermore, the city also provides ready market for food products like yam, plantain, cocoyam, okra, banana and garden egg. There is prevalence of sawmills in the city and its environs in view of the surrounding tick forest. Peels and decayed farm products are characteristically bulky and thus form the junk of the organic waste generated. All these have ultimately led to increased MSW generation in the city. Table 2 shows the increased trend in waste collected in Akure city from 2000 to 2010.

There is an increase in the waste generated but because of increased effort by government to reduce the environmental threat posed by the huge solid waste accumulation, more of the generated waste are collected and managed effectively.

Trends in Waste Generation and Collection in Akure

Generation of wastes is as old as human existence of which Akure is not an exception. Ever before the city assumed its present status and right from the inception, wastes were being generated by the inhabitants of the city. The only
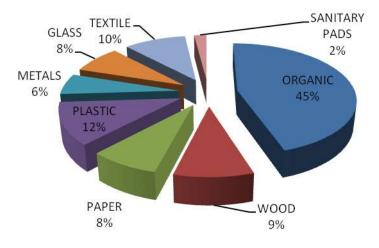
FIGURE 2
Waste Composition in Akure

TABLE 1
Percentage Composition of wastes Collected in different areas in Akure

Waste Composition	Residential areas				
	High income districts	Middle income districts	Low income districts	Commercial centres	Institutional areas
Food wastes	48.6	39.8	34.3	36.9	40.6
Paper/textiles/leathers	6.8	8.9	11.2	13.3	15.6
plastics	7.3	7.1	6.8	10.6	6.9
Glass	3.2	4.2	2.9	6.9	6.7
Metals	6.7	4.8	7.1	8.2	6.3
Sludge	5.9	7.6	8.2	3.5	8.6
Scrap tyres	5.6	4.3	2.6	6.1	6.3
Pampers/sanitary pads	7.2	6.8	3.3	0.9	1.2
Horticultural wastes	6.6	4.3	2.9	2.2	7.6
Others	2.1	12.2	20.7	11.4	0.2

TABLE 2
Municipal Waste Collected from 2000-2010 in Akure

Month/Year	Waste Collected (ton)										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
January	206	234	218	259	260	243	237	302	344	573	562
February	236	244	268	254	252	257	209	379	470	602	764
March	239	247	241	258	256	261	316	418	361	733	804
April	232	302	261	244	258	249	284	491	483	647	679
May	253	287	246	286	277	286	281	316	461	635	801
June	247	315	268	294	281	243	264	417	405	572	639
July	238	309	288	248	250	261	224	473	369	694	685
August	243	274	256	251	289	302	291	405	392	756	739
September	236	318	309	299	278	294	261	456	416	661	742
October	249	331	226	237	240	248	263	484	361	689	741
November	268	296	302	313	298	296	271	339	443	548	736
December	234	364	280	346	352	361	274	407	420	592	646
Total	2881	3521	3163	3289	3291	3301	3175	4887	4925	7702	8538

differences between then and now are the nature and the quantity of wastes generated. In the earliest time, the use of *akitan* (refuse dump) scattered all over the city was massively employed as sites for waste disposal. Domestic wastes and all kinds of wastes were regularly dumped on the sacrificed sites which also served as toilets for the people. The common practice then was to put fire on the dumpsites, especially during the dry season, to burn hills of refuse deposited over time so as to reduce dump height and volume (Ogwueleka, 2009). However, this practice has become unacceptable socially and environmentally.

These plots of land has so appreciated in value that the

owners are not favourably disposed to using them as dump sites any longer. Another factor is public awareness that open waste dump can have negative effects on human health and can lead to surface and groundwater pollution. Nevertheless, one still finds few scattered dumpsites around the city where scavengers carry out their activities. This makes it necessary to replace this primitive collection and management method with a more environmental friendly collection technique.

As a result climatic factors like high temperature and humidity with high organic matter content of the municipal wastes, MSW decomposes rapidly resulting in unhygienic conditions. Hence collection has to be done on a daily basis. At present different collection methods are being used in Akure ; house-to-house collection (primary collection), collection from roadside storage areas, street cleaning and collection of MSW from the streets, and households in handcarts. Thereafter, the wastes are dumped at one of the collection points. MSW is then loaded into transportation vehicles

trucks, tipper, tractor or automatic compaction vehicles which transport the waste to disposal sites. A handcart or tricycle, a broom and a scraper are provided to each sweeper to sweep the roads, lanes and by-lanes, to clean open drains, collect the waste, load it into the handcart and transfer the same to a secondary collection point in the form of open storage enclosures where vehicles will pack them to disposal points. MSW produced from individual households is taken to the collection point or just deposited at the adjacent roadside from where it is collected when the roads are swept. Sometimes, residents deposit their waste directly into the roadside community bins, (Figure 3) for corporation pickup.

Table 3 shows the available waste collection vehicles for both state and local Government Waste Management Agencies.

These vehicles are inadequate as a result of increase in population Akure town is experiencing There is therefore a need to repair the faulty ones and procure more waste collec-

FIGURE 3
Samples of Waste bin Distributed in Akure

TABLE 3
Available waste collection, transportation and disposal vehicles in Akure

Vehicle type	Own by state government			Own by local governments		
	Existing units	*operational*	*percentage*	*Existing units*	*operational*	*percentage*
Lorry	11	8	72.7	9	6	66.7
Tipper	7	6	85.7	6	3	50
Tractor	5	5	100	3	2	66.7
Side loader	8	6	75	5	5	100
Automatic CompactionTruck	12	10	83.3	6	5	83.3
total	43	35	81.2	29	21	72.4

tion vehicles, this will alleviate problem of waste collection because more than 90% of the waste generated would be collected by these fleet of vehicles.

Management of the Collected Wastes

Improper waste disposal habits of the citizens as well as funding for waste management agencies and their care-free attitudes have made solid waste management to suffer set back (Agdag, 2009) Realizing the need to arrest the situation, the Ondo State Government in 1999 established the Ondo State Waste Management Authority (OWMA), an agency to tackle the problem of MSWM holistically in Akure metropolis in particular and the state at large. Since the inception of the agency, many steps have been taken towards improved MSWM in the state generally and Akure in particular. So far, the agency has distributed over 15000 waste bins (Figure 3) and polythene bags at affordable costs to households within the metropolis. Besides, it has allocated waste trolleys at strategic places such as markets, hospitals, government offices and educational institutions around the city. The agency also ensures compulsory cleaning exercise at all market sites within the city every at two weeks interval during which market women are asked to clear all the wastes generated into the collection vehicles with the assistance and supervision of OWMA. This is in addition to the mandatory monthly environmental sanitation exercise which takes place between the hours of 7am – 10am every last Saturday of the month. OWMA supervises the exercise with the support of other government officials and ensures that wastes generated during the period are well managed.

In order to consolidate the success recorded with OWMA, the state government in June 2006 created out of the existing agency, Ondo State Integrated Wastes Recycling and Treatment Project (OSIWRTP). The Project commenced operation in December of the same year initially with 84 staff members (Olanrewaju, 2009). OSIWRTP was conceived to further accomplish the MSWM efforts of its mother agency; OWMA which only collect the wastes and dump them in landfills. It has the mandate of recycling MSW and thus creating wealth from it by converting MSW to organic fertilizers. The collected waste is either incinerated, deposited in a landfill while some percentage of it is recycled into organic fertilizer. This is achieved with recent installation of 150 ton/ day mechanical compost plant. The waste will be sorted into bio-degradable and non –biodegradable components after which the biodegradable part would be fed into the machine to produce compost/organic fertilizer of high agricultural value. The only challenge confronting this process is the inability of the agency to utilize the machine to its maximum capacity as waste collected daily is not enough compared to the design capacity of the equipment.

This as shown in Table 4 has made the percentage of waste that was dumped in an uncontrolled open field to be reduced considerably since the commencement of operation

TABLE 4
Management Methods for the Collected Waste

Year	Methods of Waste Management								
	Total collected (ton)	incineration (ton)	Percentage incinerated (%)	landfill (ton)	Percentage into landfill (%)	Recycled (ton)	Percentage recycled (%)	Open dumping (ton)	Percentage dumped open-ly(%)
2000	2881	801	27.8	680	23.6	-	-	1400	48.6
2001	3521	923	26.2	982	27.9	-	-	1616	45.9
2002	2963	782	26.4	913	30.8	-	-	1268	42.8
2003	3189	928	29.1	1218	38.2	-	-	1043	32.7
2004	3261	1001	30.7	1197	36.7	-	-	1063	32.6
2005	3301	1063	32.2	1390	42.1	-	-	848	25.7
2006	3175	1289	40.6	1168	36.8	-	-	718	22.6
2007	4887	2067	42.3	2136	43.7	86	1.8	626	12.8
2008	4925	2049	41.6	2039	41.4	102	2.1	733	14.9
2009	7702	3297	42.8	3497	45.4	289	3.8	616	8.0
2010	8538	3594	42.1	3807	44.6	422	4.9	716	8.4

of OSIWRTP in 2007. Although, the Project is not yet operating at full capacity, it has indeed played a complementary role to the efforts of OWMA as the operations of OSIWRTP have assisted in eradicating waste accumulation into dunghills. Figure 4 shows the quantity of organic fertilizer produced by OSIWTRP between 2007 and 2010. OSWMA also sponsors awareness campaign programmes on the electronic media on weekly and monthly basis on the need for the citizens to embrace good sanitary measures and follow the waste management procedures laid down by the agency especially in Akure. During these programmes, convicted violators of sanitary and waste management laws were shown on the television to serve as deterrent to others.

Employment of Sanitary Inspectors and Volunteer Youth Corps

Recently, the government has strengthened the Sanitary Inspectorate Department of the Ministry of Health with the recruitment of trained Sanitary Inspectors to help ensure compliance with government rules on sanitation. There are also Volunteer Youth Corps who work in conjunction with the Sanitary Inspectors to ensure that MSW are not haphazardly dumped around the city. The two groups have in no small measure inculcated sanitation habits in the minds of many inhabitants of Akure. Radio and television programmes sponsored by the volunteer youth corps have increased people awareness on importance of good waste management like usage of waste bins and other waste collection equipment. There is also punishment for people who violate sanitation laws as apprehended and arraigned sometimes in mobile/regular courts where they are sentenced to various jail terms or fined when found guilty.

Future Challenges

Waste recycling has proven to be far more costly than

originally anticipated. Factors that raise the costs are the types of materials collected, collection methods and handling strategy (Bai & Sutanto, 2002). Collection and handling costs have always formed a large component for material recycling, and the quality of waste materials separated for recycling has frequently been inadequate for direct resale Waste minimization will remain to be one of the major challenges and needs to be implemented more strictly (Hazra & Goel,2009). Currently, there is no limitation on the amount of solid waste that may be generated in Akure. While industrial and institutional solid waste may be more easily controlled, minimization of residential solid waste will continue to be difficult. Residential solid waste is not being currently charged for the generation/collection, and has no limitation/control in the actual quantity or volume of solid waste generated. Even if the regulation is revised and solid waste is to be charged on the basis of weight/volume (i.e. ''Pay-As-You-Throw''), the regulation can be difficult to implement. The quantity of solid waste from each individual household will be hard to detect and quantify. To arrest this situation, Kum *et al*. (2005), reported that the value of waste generation in Phnom Penh and a developing city like Akure in Cambodia is taken as 0.65kg/ca/day. Also, Nissim *et al*. (2004) put the value of per capita solid waste generation in Israel as 0.8kg/day. This estimation is what the two countries use to charge households for municipal solid waste generation based on number of people living in the house. A fixed household waste generation value can also be adopted in Akure so that each household would be charged based on number of people living in the house.

Economic and Environmental Benefit of Good Municipal Waste Management

The total quantity of waste generation in Akure would be increasing as long as its population grows. An annual population growth of 2.5% has been proposed for Akure, this coupled with rising standard of living and consumption pattern of
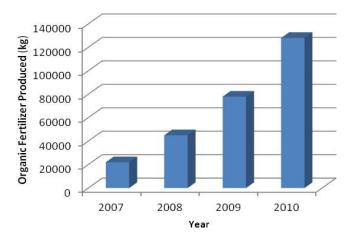
FIGURE 4
Quantity of Organic Fertilizer Produced by OSIWRTP

people, a total of 8 million ton/ year of municipal waste generation has been projected. This waste if managed properly can be of economic benefits to the town. Open dump system is still being practiced in some parts of the town and this is associated with environmental problem listed by Hamer, (2003) as emission of greenhouse gas, aesthetic blight, odour, hosting of insects and pests and can also create health problem for the populace. Rehabilitation of open dump into sanitary landfill for non-biodegradable waste and biological processes for organic waste would be a good practice. The landfill sites should be lined with impermeable materials at the bottom and sides to prevent soil and groundwater pollution. It should also contain leachate collection and landfill gas monitoring equipment. Gasification technology which involves incineration of solid waste with no supply of oxygen is also a good management method. It produces fuel gas which can be stored and used. Though there are no gasifiers in Akure at present, their adoption would go a long way to provide economic benefit from municipal solid waste. Refuse Derived Fuels (RDF) plants can also be purchased. The plant generates improved solid fuel or pellets from MSW, the pellets can be used with other conventional fuel like coal without producing any ill effect. As seen in Figure 2, MSW in Akure contains recyclable materials like plastic, paper, glass and rubber. These materials can be separated for recovery and reuse. For the organic or biodegradable component of the waste, Sharholy *et al*. (2008) recommended processes like aerobic composting, vermicomposting anaerobic digestion (biomethanation). All these treatment methods, if also adopted in Akure, would lead to production of useful products like compost which is useful for agricultural purpose and biogas with 60 -65% methane which can be used directly as fuel or for power generation.

CONCLUSION

From the foregoing, there is no doubt that a lot of successes have been recorded in MSWM in Akure owing to the commitment of the government and its agencies. The city of Akure is neater and more environmentally friendly than it was before. This study has therefore established the fact that the problem of MSWM can be reduced in urban and semi-urban cities of developing countries through appropriate attitude and approach. There is every opportunity for reduction of unemployment with the establishment of MSWM agencies. However, despite the successes recorded in Akure, the following aspects could still be employed for greater achievement.

1. There is the need to improve on the present MSWM cost sharing between the government and the people. Sustainability of the present achievement requires raising the levels of cost recovery through appropriate payment for waste services and adoption of polluters – pay - principle.
2. All agencies saddled with the responsibilities of MSWM should be strengthened with enabling law, adequate budgetary allocation and staffing to ensure that they operate at full capacity. In addition, more stringent measures should be taken to ensure that violators of sanitary laws are apprehended and punished.
3. Measures for continuous performance improvement in waste management through the culture of professionalism as well as institutionalizing best practices and high environmental standards, including occupational safety will go a long way to sustain the present efforts at MSWM. To this end, opportunity should be created for Private Sector Participation (PSP) in MSWM.
4. Citizens should be educated on the colour codes for the waste collection bins and the expected waste category to be dump inside each of them. There should be a re-orientation exercise for them on the need to see MSWM as a collective effort which should not be shouldered by government only.

ACKNOWLEDGEMENT

REFERENCES

Agdag, O.N. (2009). "Comparison of old and new municipal solid waste management systems in Denizli, Turkey." *Waste Management*, Volume 29: pp. 456-464.

Awomeso, J. A., Taiwo, A. M., Gbadebo, A. M. and Arimoro, A. O. (2010). "Waste Disposal and Pollution Management in Urban Areas: a workable remedy for the environment in developing countries." *Ame. J. Env. Sci.* Volume 6(1): pp. 26-32.

Bai, R. and Sutanto, M. (2002). "The practice and challenges of solid waste management in Singapore." *Waste Management*, Volume 22: pp. 557-567.

Chen, X., Geng, Y. and Fujita, T. (2010). "An overview of municipal solid waste management in China." *Waste Management*, Volume 30: pp. 716-724.

Geoffrey, I. N. (2005). "The Urban Informal Sector in Nigeria: towards economic development, environmental health, and social harmony." *Global Urban Development Magazine*. Volume 1(1): pp. 86-94.

Hamer, G. (2003). "Solid waste treatment and disposal: effects on public health and environmental safety." *Biotechnology Advances*, Volume 22: pp. 71-79.

Hazra, T. and Goel, S. (2009). "Solid waste management in Kolkata, India: Practices and challenges." *Waste Management*, Volume 29: pp. 470-478.

Imam, A., Mohammed, B., Wilson, D.C. and Cheeseman, C.R. (2008). "Solid waste management in Abuja, Nigeria." *Waste Management*, Volume 28: pp. 468-472.

Kum, V., Sharp, A. and Harnpornchai, N. (2005). "Improving the solid waste management in Phnom Pehn city: a strategic approach." *Waste Management*, Volume 25: pp. 101-109.

Manaf, A.L, Abusamah, M.A. and Zukki, I.M. (2009). "Mu-

nicipal solid waste management in Malaysia: practices and challenges." *Waste Management*, Volume 29: pp. 2902-2906.

Nissim, I., Shohat, T. and Inbar, Y. (2004). "From dumping to sanitary landfills – solid waste management in Israel." *Waste Management*, Volume 25: pp. 323-327.

NPC, (2009). Nigerian Population Commission end of the year reports. pp. 56-69.

Ogwueleka, T.C. (2009). "Municipal solid waste characteristics and management in Nigeria." *Iranian J. Environ. Health. Sci. Eng.*, Volume 6 (3): pp. 173-180.

Olanrewaju, O. O. (2009). "Waste to Wealth: A Case Study of the Ondo State Integrated Waste Recycling and Treatment Project," *Nigeria. Euro. J. Soc. Sci.* Volume 8 (1): pp. 319-327.

Ondo State of Nigeria (1999). An Act for the Establishment of the Ondo State Waste Management Authority, The Ondo State Waste Management Authority (OSWMA). No. 3.

Sharholy, M., Ahmad, K., Mahmood, G. and Trivedi, R.C. (2008). "Municipal solid waste management in Indian cities – Review." *Waste Management*, Volume 28: pp. 459-467.

Turan, G.N., Coruh, S., Akdemir, A. and Ergun, N.O. (2009). "Municipal solid waste management strategies in Turkey." *Waste Management*, Volume 29: pp. 465-469.

Ugwuh, U. S. (2009). "A Glance at the World: The State of Solid Waste Management in Nigeria." *Waste Management*, Volume 29: pp. 2787-2790.

SOLID WASTE MANAGEMENT PLANNING USING MULTI-OBJECTIVE GENETIC ALGORITHM

Warangkana Sornil

School of Social and Environmental Development, National Institute of Development Administration
118 Seri Thai Road, Klong Chan, Bangkapi, Bangkok 10240 THAILAND

Email: warangkana.s@nida.ac.th
Tel.: +662-727-3128, Fax: +662-377-6464

ABSTRACT

Solid waste management is a complex issue, involving economic, technical, legislative, and environmental aspects. Decision makers should be assisted in identifying different alternatives and selecting the one best suited for their environments. In this research, a graph-based, multi-objective optimization model is proposed for a distributed waste management environment with multiple sources of wastes, multiple types of materials, local processing, and waste transfer routes, taking into account the net cost of the system and volume to the landfill. The non-dominated sorted genetic algorithm-II (NSGA-II) is employed as the optimization technique. The proposed technique was applied to the context of Saraburi Municipality, Thailand. The results show that the proposed model can generate better solutions than that of the current practice, in particular, lower net cost with less volume of waste to the landfill.

Keywords: Waste management; multi-objective optimization; genetic algorithm

INTRODUCTION

According to Public Health Act of Thailand, local administrations have a responsibility to manage solid wastes generated in their responsible area. Their tasks include waste collection, transportation, and disposal. Solid waste management is a complex issue, decision makers face with the complexity of the problem, including economic, technical, legislative, and environmental aspects. Many decision variables must be accounted for, and the number is rising exponentially with problem dimensions. Inadequate analysis of the problem can lead to poor decision making. As the complexity of problems faced by decision makers and society as a whole has increased, the decision makers should be assisted in identifying different alternatives and selecting the one best suited for their environments.

Optimization models have been proposed to assist with the waste management planning activities. Some relied on one single objective function (generally cost), neglecting oth-er important objectives such as social and environmental aspects. In particular, Chang and Chang (1998) developed a non-linear model taking into account waste streams from facilities, landfills, transfer stations, and incinerators. The model included pre-treatment plants and technical specifications of the incinerator. Fiorucci et al. (2003) proposed a quadratic model characterizing waste streams according to their merceological class (paper, plastic, wood, metal, etc.) and selecting potential locations for waste-treatment plants in order to minimize total annual cost.

A planning methodology cannot be restricted to economic implications alone. For example, landfill frequently represents the most convenient solution according to cost criterion but is nevertheless often the least desirable solution from an environmental point of view. In reality, different conflicting objectives are generally involved. This creates the need to apply multi-objective optimization methods taking into account the decision makers' several preferences. Most multi-objective optimizations in waste management are applied to