ABSTRACT To meet the goals of sustainable society, Taiwan Environmental Protection Administration (TEPA) initiated “Zero Waste Policy” for municipal solid waste (MSW) in 2003. The policy reflects the shifting philosophy of waste management from end-of-pipe treatment to source reduction and resource reutilization. The zero waste objectives are based on the volumes of MSW collected in 2001. The goals of volume reduction are set at 25%, 40% and 75% by the end of 2007, 2011 and 2020. The policy lays out four major strategies: source reduction, reuse, recycling and green consumption.

TEPA has taken the following major measures to recycle MSW:

In 1997, TEPA initiated the so-called “Four-in-One Resource Recycling Program”, which coordinated the efforts of the public, recycling businesses, municipalities, and the recycling fund for a comprehensive recycling of items listed under the EPR programs.

Since 2000, Taipei City government has initiated the implementation of a “Per-Bag Trash Collection Fee,” based on the principle of “Pay As You Throw.” Citizens must pay for and use specific trash bags for trash to be collected by the City government. This policy has successfully reduced the waste volume by 23% and boosted the recycling volume by 22%.

Since 2000, Taipei City government has initiated the implementation of a “Per-Bag Trash Collection Fee,” based on the principle of “Pay As You Throw.” Citizens must pay for and use specific trash bags for trash to be collected by the City government. This policy has successfully reduced the waste volume by 23% and boosted the recycling volume by 22%.

The “Mandatory Garbage Separation” rule has been implemented since 2006. The public are required to sort garbage into three categories before pick-up, namely the recyclables, kitchen wastes and trash. And the “Bulky Waste Recycling Plan” has been implemented since 2004. Waste furniture are repaired and refurbished for reuse.

Since July 2002, TEPA has adopted “Restriction on the Use of Plastic Shopping Bags and Disposable Tableware” rule, “Restriction of Excessive Packaging” rule and other measures to reduce MSW. On the other hand, regarding non-rechargeable alkaline manganese batteries and manganese-zinc batteries containing more than 5 ppm of mercury, TEPA has prohibited the manufacturing, import, and sale from September 2006.

The waste collected for landfill or incineration per capita per day has dropped from the peak of 1.14 kg in 1997 to 0.482 kg in 2010. The waste reduction achieved is remarkable. The recycling volume has increased from 0.366 million metric tons in 1998 to 3.89 million metric tons in 2010. The recycling rate of MSW also rises from 3.96% in 1998 to 48.84% in 2010.

**Keywords:** MSW collection, Recycling, Zero waste policy, Taiwan
ABSTRACT Waste reduction and recycling has an important role in Hong Kong’s waste management strategy. About half of Hong Kong’s Municipal Solid Waste (MSW) is now recovered for re-use or recycling. Much of this could be attributed to the concerted efforts of the community to implement source separation of waste in domestic and commercial/industrial buildings since 2005. This paper aims to present Hong Kong’s experience in implementing source separation of waste as well as other waste reduction and recycling initiatives, and the challenges ahead in further reducing wasteloads in the city.

Keywords: Waste recovery; Waste recycling; Waste reduction; Waste separation

Introduction

Hong Kong now relies principally on landfills to treat its MSW, which comprises domestic, commercial and industrial wastes. About 3.3 million tonnes of MSW were landfilled each year. The remaining capacities of the three strategic landfills will be exhausted starting from mid to late 2010s. To address the serious and imminent waste problem in a holistic manner, the Government published the Policy Framework for the Management of Municipal Solid Waste (2005-2014) (Policy Framework) in December 2005, which set out a comprehensive waste management strategy consisting of a series of tools and measures to tackle the waste problem ahead.

Source Separation of Waste

A key element of the waste management strategy is to reduce waste at source. Over the years, encouraging results are progressively being achieved. Since the launch of the Policy Framework in 2005, an overall MSW recovery rate of 49% has been achieved, with 35% and 60% recovery of domestic waste and commercial/industrial waste, respectively. It overshoots the MSW recovery target laid down in the Policy Framework (of 45% by 2009 and 50% by 2014). The overall landfill disposal of MSW has recorded a cumulative decrease of 3.8% from 2004 to 2009, with a remarkable cumulative reduction of 14.5% of domestic waste alone. Figure 1 below shows the summary statistics on MSW recovery and disposal in Hong Kong over the past few years.

Figure 1. Statistics on MSW recovery and disposal in Hong Kong

Much of these achievements could be attributed to the concerted efforts of the community to implement source separation of waste in domestic and commercial/industrial buildings since 2005. Apart from placing three-coloured waste separation bins all over the city starting from 1998 to promote recycling of paper,
metals and plastics, the Government rolled out a territory-wide Source Separation of Waste Programme (SSW Programme) in January 2005.

The SSW Programme aims to enhance recycling by encouraging building owners and managers to set up waste separation facilities at locations as close as possible to sources of waste generation. For example, waste recycling bins are placed on every floor of multi-storey buildings whenever possible to provide convenience for residents to deposit recyclable waste. Funding support is provided through an Environment and Conservation Fund (ECF) to the placement of recycling bins in buildings. To facilitate the SSW Programme, legislation was enacted in 2008 to require new domestic buildings and the domestic part of new composite buildings to provide a refuse storage and material recovery room on every floor to ensure that buildings have space to accommodate recycling facilities. Other than multi-storey buildings, residents in rural villages are encouraged to use recycling bins placed in communal refuse collection points. In addition, apart from paper, metals and plastics, the range of recyclables collected are expanded to cover recyclables such as old clothes, waste electrical and electronic equipment (WEEE) etc. The SSW Programme is now operating in over 1,600 housing estates, 660 commercial/industrial buildings and 700 villages, with over 80% of Hong Kong's population having convenient access to source separation facilities.

The Government is supporting the SSW Programme with territory-wide and district-based publicity campaigns, such as TV and radio announcements, advertisements in newspapers and on public transport, talks, exhibitions and road shows, as well as specific promotional programmes targeted at individual housing estates, businesses and schools. An annual commendation scheme and award presentation ceremony is organized to boost participation in practicing source separation of waste. The business sector is also encouraged to practise waste reduction and recycling through the Hong Kong Awards for Environmental Excellence under which “WastewiSe Label” will be presented to companies and organisations. Regular environmental education programmes for schools are conducted, and schools are encouraged to stop using disposable lunch boxes. In this connection, the ECF provides a subsidy for existing schools to carry out necessary upgrading works to adopt on-site meal portioning where possible.

To broaden the participation in waste reduction and recycling, the Government will continue to expand the SSW Programme, including extending the coverage of the programme to some older districts as well as rural areas; operating waste recycling activities in convenient public areas to facilitate collection of recyclables from the community; and rallying the support of all government departments with close interface with the public in waste reduction programmes to demonstrate a visible commitment of the Government. With all these efforts in place, we have committed to raise our target of MSW recovery rate to 55% by 2015.

Support to Waste Recycling Industry

Most of the materials recovered in Hong Kong are exported to Mainland China and other countries for recycling mainly due to the high land premium and labour cost which affect the economic viability of setting up local recycling facilities. In order to encourage investment in more advanced technologies and value-added processes for the recyclables in Hong Kong, the Government has set up a 20-hectare EcoPark to provide long-term land at affordable costs for leasing by the recycling and environmental industry. The EcoPark is developed in two phases. Tenancies of all six lots in Phase 1 have been awarded for recycling of waste cooking oil, metals, wood, computers, plastics and batteries. The construction works of Phase 2 has been substantially completed and will be available for open tendering in early 2011. A multidisciplinary management company has been engaged to manage, maintain and promote the EcoPark as well as to assist tenants in all matters related to construction, commissioning and operation of their recycling plants.

Besides, the Government has set up two waste recycling centers in EcoPark for WEEE and waste plastics in order to promote local processing of WEEE and waste plastics in Hong Kong. The two centers are run by two non-profit organisations with subsidy from the ECF. Apart from long-term land at EcoPark, short-term tenancy sites are also made available for bidding by waste recyclers. As at end 2010, 33 sites with an aggregate area of 5.8 hectares have been leased exclusively to the recycling trade.

Apart from land support, the Government is adopting green procurement policies such as developing mandatory “green” specifications for more commonly used items in the Government, such as stationery and office supplies, to create market demand for “green” products, thus promoting a circular economy. The
Government also supports and encourages research and development in new recycling technologies through the ECF, Innovation and Technology Fund, and funds for the small and medium enterprises.

**Policy Instruments to Further Reduce Waste**

Incentives to promote waste recovery and recycling were introduced with the passage of the Product Eco-responsibility Ordinance in 2008 which provides a legal basis to introduce producer responsibility schemes (PRSs) for manufacturers, importers, distributors, retailers and consumers to share the eco-responsibility for reducing, recycling, and disposing of end-of-life products. The first such scheme, a 50-cent levy on each plastic shopping bag, has been introduced since July 2009 to discourage the indiscriminate use of plastic bags. The Government has identified WEEE as the next target for mandatory PRS and is engaging with relevant trades on implementation details. In parallel, the Government will continue to promote and support voluntary PRSs by relevant trades for recycling of rechargeable batteries, fluorescent lamps, glass containers, computers and WEEE.

A study of overseas experience shows that any further attempts to significantly raise the MSW recovery rate would not be possible in the absence of major economic incentives/disincentives such as MSW charging, and that effectiveness of the charging scheme would hinge largely on the implementation of associated measures in waste collection and the delegating of sufficient powers to waste collectors. Owing to the unique city fabric of Hong Kong and the way the city’s municipal waste is being collected, the implementation of waste charging would pose significant implementation challenges. A broad framework on the principles and pros and cons of waste charging options will be presented for public engagement in 2011.

**Bulk Waste Reduction and Final Disposal**

Notwithstanding these efforts and achievements in promoting waste reduction and recycling, there is still a large amount of residual waste that cannot be eliminated. As the three strategic landfills are reaching capacity starting from mid to late 2010s, the Government is planning to develop integrated waste management facilities with incineration as core technology and associated sorting plants to recover recyclables mixed in the waste; as well as centralised organic waste treatment facilities adopting biological treatment technology to address the food/organic waste generated in Hong Kong. Even with the above waste reduction and recovery measures as well as advanced waste treatment facilities, the extension of the existing landfills is still necessary to cater for unavoidable and non-combustible waste and incineration ashes.

**Community Support**

A comprehensive approach to waste reduction, recycling, treatment and disposal is essential for Hong Kong to manage its waste in a sustainable manner. Active support and participation from different sectors of the community is vital for the various planned initiatives to be implemented successfully. In this connection, the Government will continue to engage the public to promote consensus on the necessary means to manage our waste.
THE U.S. SOLID WASTE PLANNING EXPERIENCE AND INSIGHTS FOR RAPIDLY ADVANCING NATIONS

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ABSTRACT The United States has accumulated more than 100 years of experience in regulating societal throwaways by passing environmental laws to manage one of the highest per capita waste generations in the world. The first solid waste related legislation was passed in the last decade of the 19th century for controlling indiscriminate dumping in the oceans, rivers and other water bodies. A succession of major environmental laws, including those for managing rejectamenta, was approved in the 1960s, 1970s and 1980s. The U.S. solid waste policy as a result of these laws and regulations has accomplished safe disposal of municipal, industrial and other commercial discards by improving upon the design and engineering of facilities. However, in the past two decades there has been an impasse in the enactment of new laws and amendments to the old ones. Political gridlock revealed by the increasing partisan politics in the Washington D.C. is preventing further environmental statutes and making it harder to make changes in the existing ones that are so desperately needed to overhaul regulations and reduce the amount of waste going to the landfills and incinerators. While the federal policy and guidelines encourage 50 states and over 40,000 local governments or administrative regions including municipalities and counties to reduce and recycle waste, they are lacking resources and tools for achieving the un-mandated national goals. Many states in the Northeast, Midwest and West Coast have achieved significant milestones in reducing and recycling waste generated within their boundaries. However, a majority of the states in the south and sparsely populated west are lagging in putting a dent on the increasing amount of refuse disposed at landfills or incinerated. The vast size of the country, the low density of population and the relatively inexpensive lands are partly to blame for the current practices of waste management. The costs for purchasing lands for new landfills are a small part of the overall expenses for burying waste under the ground. Therefore, landfilling remained the preferred choice of disposal. The takeaways from the U.S. experience for economically rising nations are many. First, solid waste laws and regulations are essential for rapidly industrializing nations to reduce the occurrences of environmental catastrophes. Secondly, passing new laws or implementing policy may not be difficult at the early stage of economic advancement before special interest groups gain strength and throw gauntlets opposing changes in the status quo. But a culture of regulatory infrastructure and unwavering commitment for enforcement of laws are imperative. With the hindsights of the U.S. experience in crafting solid waste laws and regulations and their implementation, the booming economies should be able to devise customized policy and management to suit their own needs and unique historical, cultural, and economic realities. Each country must come up with its own solution to curtail the negative impacts of ever-expanding industrial and municipal trash in the light of its political and institutional advantages and barriers. When it comes to solid waste management, one set of tools will not be justifiable for countries on a continuum of industrial and economic development.

Keywords: U.S. solid waste laws, Regulations, Planning

Introduction

The objective of this paper is to weigh in on more than ten decades of the U.S. solid waste experience and shed lights on policymaking for countries that are experiencing rapid industrialization. The recommendations are not specific guidelines but point to areas of potential improvements that may assist in reducing the ill effects from the rising trash volume. The paper briefly discusses the U.S. experience in improving and managing solid waste collection and disposal in the last one and a half century, and its attempts to reduce and recycle refuse. The underlying premise is that the U.S. experience of escalating waste volume resulting from rising living standards and industrial output has parallels in emerging polities. But the permutation of socio-economic variables will determine the specific set of waste management policies. With the higher per capita income, literacy rate and the changing value system, the citizens of rapidly developing countries are expected to become more environmentally conscious, demanding more waste reduction and recycling.
Historical Background

Communities across the U.S. did not provide solid waste collection as a municipal service in the middle 19th century. But as the country was growing economically and population increasing with massive immigration and natural growth, cities were faced with the crisis of garbage being thrown on the streets for animals to lounge upon and scavengers to recover resources. Municipalities began to provide refuse collection services in the third quarter of the 19th century; disposal was primarily in the form of burning or burying in the open dumps and/or discharging into rivers and oceans [1]. The pre-automobile transportation technology limited the expansion of urban areas throughout most of the 19th century, and it did not make it easier for removing waste from the city streets. The oldest environmental law, the Rivers and Harbours Act of 1899 which is also known as the Refuse Act, has a provision for making garbage dumping into navigable waters illegal. Emerging nations without such laws may consider adopting them to protect their inland waters and ocean fronts. Such ban on ocean and river dumping will improve the water quality and chances for better diplomatic relationships with neighbouring countries in case washed away solid waste is creating tensions with abutting nations.

Waste collection has improved in urban areas of the U.S. as the 20th century dawned on and when truck transportation became ubiquitous for efficient removal of waste. But the disposal of solid waste continued to be characterized by open burning, incineration and underground burying. The geographic size of the country with a relatively smaller population combined with better transportation attributed to such waste management practice for quite sometime and well into the 20th century. However, as the U.S. population was rapidly increasing and industrial growth accelerating, especially after the 2nd World War, waste generation expanded significantly and its management was increasingly becoming an issue. The rising standard of living and the use of new consumer products packaged in plastic wrapping added to the escalating waste volume [2].

Implications of Major U.S. Solid Waste Laws

Waste management practices of the 1950s and 1960s in the U.S. are reminiscent of refuse handling in countries encountering rising middle class and higher disposable income. The widespread practices of open-burning and land dumping in many U.S. communities during this era are repeating five decades later in rapidly growing metropolises of many countries. Lack of regulations led to dumping of liquid hazardous waste in many American rivers contributing to their catching fire indiscriminately. The territorial extent of the U.S. comparable to China but with 1/4th of its population assisted in absorbing the environmental impacts of increasing refuse volume and delaying in taking major precautions. Many emerging nations with much higher population density and not much land to spare for disposal may not be able to afford waiting too long for adopting solid waste strategies and avoid such unfortunate incidences.

Three sets of U.S. solid waste laws are particularly relevant for countries willing to reduce environmental consequences from increased garbage generation: a) Solid Waste Disposal Act, b) Resource Recovery Act, c) Resource Conservation and Recovery Act. The debate over what to do with the mounting throwaways started before the 2nd World War ended in 1945 with the United States Public Health Service (USPHS) put in charge of the solid waste program; the discussion continued after 1970 when the United States Environmental Protection Agency took over the responsibility and created the Office of Solid Waste. Although the USPHS was not a regulatory agency, it managed to raise public conscious about the health and environmental impacts of solid waste disposal and lobbied for the passage of the country’s first significant Solid Waste Disposal Act (SWDA) in 1965. Two primary purposes of SWDA was to a) encourage research and development in solid waste disposal and resource conservation by reducing the amount of refuse and increasing recovery, and b) “to provide technical and financial assistance to state and local governments and interstate agencies in the planning, development and conduct of solid waste disposal programs” (U.S. Congress 1965). The U.S. Congress being the primary legislative body at the federal level defined “State”, “Interstate Agency”, “Solid Waste”, and “Solid Waste Disposal” in the SWDA [3]. The provisions of SWDA may be beneficial in developing new policy and in the preparation of nascent solid waste legislations. State and local governments were assumed to be responsible for solid waste management and the federal role would be limited to passing a national legislation to guide the former. Geographically large countries may want to replicate this model of three-tier administration to stimulate creativity in the implementation of a national agenda at the state, provincial and local level governments. The flexibility of
the federal policy and legislation will allow lower tiers of government to design their laws and regulations within the realm of their regional peculiarities.

The SWDA was the beginning of the federal involvement but needed overhaul immediately following its passage to improve upon the prevailing refuse management. It did nothing to stop the open burning at solid waste dumps and concerns for amendment became imperative. The proximity of a well-known disposal site Kenilworth Dump near Washington D.C. burning trash on a daily basis and wind carrying smoke to the direction of Capitol Hill housing the U.S.Congress, played a key role in raising awareness about remediating the pervasive problem of waste management among legislators. Engineers at the Office of Solid Waste, USPHS and academics were still not sure about the long term policy for disposal and collection [4]. However, research supported by the SWDA and funded by the federal government continued and led to a better understanding of issues related to the management of solid waste. The SWDA was amended by the Resource Recovery Act (RRA) of 1970 which kept some of the original provisions, replaced others with the newer ones and added more to reflect the research findings [5].

The hindsight of the early U.S. experimentation reveals takeaways for nations with limited experience in policymaking. First, the execution of new enactments must take into consideration the mix of solid waste origination from residential, commercial, industrial and agricultural activities and their proportionalities. Second, the types of solid waste vary across countries: rubbish and garbage from households, construction and demolition debris, commercial waste from businesses and industries including hazardous wastes. Research on waste characterization will determine the relative importance of each solid waste category. Third, the nature of collection, storage, handling and processing will also play a role in the crafting of new policy and laws. Fourth, the extent of the prevailing practice in the discharge of waste to the environment and the social, political, technological and environmental constraints must play a critical role in decision-making. Fifth, the recovery and recycling rates in the most rapidly advancing countries are much higher than in the U.S. because of wage differences and demand for recyclables which will influence specific sections of legislations dealing with their separation and processing into feedstock for industry. The high cost of labour-intensive processing is a contributing factor towards export of recyclables from the U.S. to countries where wages are much lower. A healthy and open debate among solid waste professionals, industry representatives, academics and researchers should precede the concoction of any proposals.

Federal enforcement and increase in authority over the national policy did not arrive until the signing into the law of the Resource Conservation and Recovery Act (RCRA) in 1976, amending the SWDA and RRA [6]. The RCRA divided waste streams into hazardous (Subtitle C) and non-hazardous solid waste (Subtitle D). The objective of Subtitle D is to design federal guidelines for state and regional solid waste plans, establish criteria for sanitary landfills for most disposal needs and upgrade open dumps to sanitary landfills. Until the passage of the RCRA, the 50 states in the union had limited role in managing and controlling solid waste generated within their boundaries. However, with the federal grants since the passage of SWDA and additional funding authorized by RCRA, states began accumulating better understanding of their collection, storage and disposal practices. States designated a single agency whose sole purpose would be to handle solid waste issues to meet federal requirements for receiving grants. In the early 1960s, most states would have only a handful solid waste professionals assigned to an agency whose responsibilities will also span to issues related to health, air, and water. Soon states passed their own solid waste legislations within the federal standards and developed design criteria for sanitary landfills. Some states like Missouri adopted RCRA early enough to integrate it into their enactments and were able to close most of the old dumps. By the late 1980s and early 1990s old dumps in communities across the U.S. began to be replaced by sanitary landfills with liners, heavy clay and other barriers to protect the groundwater from contamination. This is also the time when some states in faced crises related to the lack of landfill space. Images of barges full of solid waste sailing around the world to find disposal sites had been etched into the memories of many solid waste mandarins. The solid waste industry responded and built newly engineered sanitary landfills to meet the demand for growing discarded volume. Since then the disposal cost has stabilized throughout most of the U.S. except in the east where higher population density and cost of living contributed to relatively more expensive disposal.
Solid Waste Planning for Waste Reduction and Recycling

Many countries outside North America and Europe will not be able to afford the luxury of relying totally on landfilling their waste because a closer proximity of such sites to human settlements will be unavoidable under most circumstances. The vast unused lands in the U.S. have easily allowed the expansion of landfilling which remained the primary method for getting rid of unwanted materials. The clean air regulations forcing higher cost of burning have forced many incinerators out of business and alternatively made landfilling cheaper in most parts of the U.S. The territorial extent of the U.S. with over 9 million square kilometres of land (3.5 million square miles) and a relatively smaller population of 311 million (2011 estimate) are also making it difficult for waste reduction and recycling programs to put a dent on the amount of solid waste being landfilled and incinerated. Landfilling is still the most popular choice for more than half of all municipal solid waste (MSW) disposal. According to the United States Environmental Protection Agency (USEPA), the MSW generation has been increasing every year for the past few decades [7]. The most recent decline in MSW production in 2009 is primarily due to the slower economy not generating much discards. Although recycling rate is increasing in the U.S., it failed to rein in the rising tide of refuse. The golden era of solid waste legislation ended with the amendment of the RCRA in 1984, and new legislative efforts for change in favour of waste reduction and recycling will be difficult to come by. The private solid waste industry was very active during the passage of major enactments and has invested heavily in sanitary landfills and associated infrastructure which is the most lucrative sector of its business. The regulatory environment created by the USEPA has been under attack for raising the cost of doing business. The emerging Latin American, African and Asian countries may have a totally different political and institutional environment where adoption of policy or the passage of new legislations to reduce environmental externalities and encourage waste reduction and recycling may not be difficult.

Conclusion

The U.S. solid waste management is an incomplete success story as provisions for reducing landfilling and incineration of societal throwaways remains inadequate. The RCRA and its amendments have solved the landfill crisis and increased the safe and sanitary disposal of solid waste, but so far they have been unsuccessful in strengthening waste reduction and recycling. The prevailing political and economic milieu is not amenable to amending existing environmental laws in favour of more recycling. Some states failed to develop waste plans for lack of a USEPA mandate, but most have prepared and updated them periodically; a majority also require their local governments to develop and implement plans which now cover most of the U.S. territories. Waste reduction and recycling goals have been set by the USEPA and states have similar benchmarks for municipalities, counties, parishes and boroughs. But the funding opportunities to support such measures have remained insufficient and therefore negatively impacting upon community recycling programs. The recycling industry has struggled over the last three decades for low market demand for recyclables, but recently experienced growth despite economic recession. However, recycling processing facilities are not getting enough feedstock for lack of an adequate infrastructure for collection of recyclables in many parts of the country as community supported drop-off and curbside or kerbside recycling is limited in many parts of the country.

Despite shortfalls the U.S. framework for passing legislation at the national level to provide guidelines for states, provinces and regional governments is a replicable model. The qualities of a good federal legislation lie in its flexibility, applicability and adaptability for administrative regions. It is essential to realize that without any policy framework and the laws and regulations to implement them, the environmental impacts from solid waste generation and disposal will be difficult to control. Expertise for crafting and implementing policymaking is already there in the advancing nations, which could be supplemented by utilizing expatriates with relevant experience living and working overseas in industrialized countries. What is needed is the leadership in each country and the desire for tapping into this existing knowledge pool. The recommendations here are not intended to copycat the U.S. strategy but to suggest that fast industrializing countries will benefit from the American experience in its legislative efforts and research and development in waste management. Economically prosperous countries like Japan with over 50% recycling rate and much higher population density may provide a better model for some countries. Germany with its Green Dot program is worth examination. It is prudent to investigate policymaking in developed and advancing countries before settling on a set of policy. The first attempt towards formulating
a long-term public policy is to start a dialogue and carry out research to increase an understanding of the existing solid waste management. A panel consisting of local experts, academics, government officials, environmental groups, industry representatives and expatriates with the knowledge of their native countries as well as their adopted homelands will provide an appropriate forum for starting such debate.

References
RECYCLING: A VIEW ON DEVELOPING TECHNOLOGIES

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Recycling has taken a large flight in recent years. Nevertheless, recycling and reuse have been at the heart of the often informal waste management practices all over the world.

In this presentation a review of state of the art recycling technologies will be made, assessing their possible use in the Asian context. The focus will be on plastics and WEEE recycling.

Keywords: Recycling, Waste management practice, Recycling technologies, Plastic recycling, WEEE recycling
SUSTAINABLE SOLID WASTE MANAGEMENT APPROACH IN KATHMANDU: POSSIBILITIES & CHALLENGES

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ABSTRACT This paper highlights the current status of solid waste and an existing solid waste management system practiced in Kathmandu. Composting, waste to energy technologies such as refuse derived fuels (RDF), biogas followed by 3R principles (reduce, reuse, and recycle) rather than land filling are proposed in managing solid waste of Kathmandu for sustainable and healthy environment. The data showed that over 64% of solid waste comprising of biodegradable in Kathmandu which could be composted followed by meticulous segregation. Compost technology reduces the waste without need for incineration and land filling helping to reduce the contribution of greenhouse gases to global warming. Similarly, waste to energy technologies have several advantages which reduce landfill dumping, dependence in fossil fuels, greenhouse gases emissions and improve environmental condition. Therefore, this paper compares the different approaches and discusses the most economical and best option possible to combat the waste disposal problem in Kathmandu.

Keywords: Composting, Solid waste management, Sustainable, Waste to energy, 3R principles

Introduction
The challenges of the solid waste management (SWM) sector are continuing to grow with the growing urbanization along with its increasing human activities. In the early days, solid waste disposal did not pose difficulty as habitations were sparse and land was plentiful. Solid waste disposal became problematic with the rise of towns and cities where large numbers of people started to congregate in relatively small areas in pursuit of livelihoods [1].

Before 1970, the solid waste in Kathmandu valley, the main urban centre and capital city of Nepal, was locally managed. Increasing population, changing lifestyles and negligence towards preservation of environmental condition brought new scenario of urban and rural areas where dumping of solid waste has become regular phenomena. Inappropriate management of urban solid waste not only increases the pollution to the environment, but also threatens human health through its collection, transfer and disposal processes [2]. With the growing population and urbanization, the traditional system of waste management was gradually replaced by the modern and scientific approach to some extent since earlier 1980 [3]. Despite of significant efforts in the last decades, increasing volume of solid waste could not be managed, which has created a serious environmental and public health problem of more than three million people residing in Kathmandu valley. At the same time, as a result of haphazard dumping on poorly designed and operated landfill site, local people nearby landfill site frequently blockade and obstruct the solid waste dumping which has further deteriorated the environmental situation of Kathmandu. Therefore, it must handle the issue of solid waste management in Kathmandu peremptorily and effectively.

There have been few overview studies of MSW management in Kathmandu. This paper presents current status of solid waste and an existing solid waste management system practiced in Kathmandu, firstly. Secondly, different SWM approaches followed by 3R principles (reduce, reuse, and recycle) are proposed in managing solid waste of Kathmandu for sustainable and healthy environment and finally discusses the possibilities and challenges of different approaches and recommends the most economical and best option possible to combat the waste disposal problem in Kathmandu.

Background of Solid Waste Management in Kathmandu

Municipal Solid Waste (MSW) Generation and Characteristics
In Kathmandu, general sources of solid waste are domestic, industrial, agricultural, institutional and natural. Domestic waste is the main source of solid waste, followed by agricultural and industrial wastes in
Kathmandu. Total solid waste generated all over the country (for a population of 25 million) is believed to be around 8,500 T/day, out of which 29% belong to Kathmandu alone [4]. The MSW generation rate in Kathmandu valley has increased steadily over the last 30 years, from 0.25 Kg/day/person in 1978 to 0.469 Kg/day/person in 2010. This can be attributed to a rapid population increase and economic development. Figure 1 shows the relationships between population and MSW generation in Kathmandu valley over last 30 years.

The typical characteristics of MSW in Kathmandu valley include very high moisture content (45 to 50%) with compostable biodegradable waste (65 to 75%). The recyclable and market waste comprising around 20% are packaging materials, plastics, glass, paper, wood, cans, and metal. The balance waste comprising of 16% is the inert materials as construction debris, earth, sand and dust that require sending to landfill sites or to land reclamation sites [4].

Figure 1. Relationship between population and MSW generation rate in Kathmandu valley over period of 1978 to 2010

Current SWM Practice in Kathmandu

The current practice of SWM comprises of producing mixed waste, through a series of mixing activities from the source of generation at household level until it reaches the final disposal site. Huge amount of capital resources is spent for mixing procedures during the process of collection, transfer and dumping. All generated waste goes to dumping sites for disposal. With the all type of solid waste, valuable resources also go for dumping. It is not considered as a proper and sustainable manner to manage the solid waste in this way.

Resource Oriented Sustainable SWM Approach

Waste is not only a jumble of garbage but also a source of valuable materials. Among various components of waste hierarchy, reduction of waste at source is most important and needs active participation of individuals, communities and institutions. Therefore, the present practice of SWM (street sweeping, collection, transportation and disposal of in the dump yards) has to be changed as resource oriented sustainable SWM by the concept of 3R through involvement of private sector. Based on characteristics of the MSW in Kathmandu, combination of following resource oriented SWM approach are proposed for managing waste in sustainable and environmental friendly way.

Composting

Composting is an aerobic digestion process which breaks down the biodegradable component of the waste with aerobic microorganisms to produce into carbon dioxide and compost fertilizers. From several past studies, over 64% of solid waste comprising of biodegradable in Kathmandu valley which could be composted which suggests composting will be more appropriate and sustainable technology for managing SW. Total solid waste generated in Kathmandu valley, compostable waste and possible production of compost from compostable waste for different years are presented in Figure 2. Estimation for 2006 and
2011 was computed based on the survey data conducted by JICA on 2004 [5]. The possible compost production estimation was computed as 30% compost recovery from compost materials.

Figure 2. Total solid waste generated, compostable waste and possible compost production (Estimation for 2006 and 2011 based on survey data by JICA study team in 2004)

Waste to Energy Approach

The term “waste to energy” has traditionally referred to the practice of incineration of garbage. Today, a new generation of waste-to-energy technologies is emerging which hold the potential to create renewable energy from waste matters [6]. The main categories of waste-to-energy technologies are physical technologies, which process waste to make it more useful as fuel such as refuse derived fuel (RDF); thermal technologies, which can yield heat, fuel oil, or syngas from both organic and inorganic wastes; and biological technologies, in which bacterial fermentation is used to digest organic wastes to yield fuel.

RDF is a fuel produced from combustible fraction of solid waste by either shredding solid waste or treating it with steam pressure in an autoclave. This process reduces the volume of the waste by up to 60%, and the residual material can then be compressed into pellets or bricks and sold as solid fuel. Burning RDF is more clean and efficient than incinerating MSW or other solid waste directly, but the processing add to costs. High moisture content and less calorific value of MSW in Kathmandu reduce the efficiency of RDF process which needs addition of fuels or meticulous separation to increase calorific value for the efficient and cost effective RDF process. Since MSW of Kathmandu contains significant amount of food processing waste or other agricultural waste such as manure, biogas can be produced installing biogas plant where anaerobic digestion of waste can occur in a controlled environment. The biogas can then either be burned directly in boilers, or cleaned and supplied as natural gas. Biogas plants can also transfer electrical energy to the main utility grid.

Conclusions

The quantity of MSW has increased markedly in the last three decades in Kathmandu and will continue to increase in the future. The gap between total designed capacity of facilities and actual MSW generation rate should be solved. Hence, combinations of compost and waste-to-energy technologies followed by 3R principles are recommended. These approaches and technologies effectively solve the solid waste problem currently facing in Kathmandu in one hand and reduce landfill dumping, dependence on fossil fuels, greenhouse gases emissions and pollution in other hand. In addition, these technologies are eligible for carbon credits and tax incentives by replacing fossil fuels.

References


DEVELOPING INTEGRATED WASTES MANAGEMENT PLAN IN SUDAN

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ABSTRACT Developing national policies and strategies in Sudan to promote a balance between the economic growth and natural resource conservation are crucial to achieve environmental sustainability. To fulfill that charge within the scope and objectives, the innovation of Integrated Waste Management Plan (IWMP) within the spectrum of the existing legislation would be started soon. This requires assessing life cycle of wastes, ensuring sufficient land disposal capacity, and identifying required green technologies for reducing, re-using and re-cycling the wastes in urban and rural communities. Enhancing national capacity in IWMP, raising awareness in the culture of waste disposal and developing ad hoc media campaign will strengthen the efforts towards IWMP. Encouraging partnership between authorities and private sector by adopting the BOOT system will satisfy the needs of today’s waste management system and the economy that depends upon it. At the same times, will encourage the development of waste-to-resource systems that reduce waste destined for disposal, with the dual aims of alleviating the impacts on people health and environment and enhancing economy and quality of life. This initiative is considered top priority within the national decade declaration (2010-2020) of safe waste disposal management.

Keywords: Integrated Waste Management Plan, Green technologies, Partnership, BOOT system, National declaration, Safe waste disposal

Introduction

Waste management practices throughout Sudan are uniformly poor. Management is limited to organized collection from the more affluent urban areas and dumping in open landfills or open ground. In the majority of cases, garbage of all types accumulates close to its point of origin and is periodically burnt. Litter – plastic bags in particular – is a pervasive problem across the country, with Khartoum state being worst affected due to its population density and relative wealth. UNEP field teams visited a number of municipal dumpsites in Port Sudan, Khartoum, El Obeid, El Geneina, Wau, Juba, Malakal and Bor, as well as in smaller towns and villages. Of all of the sites visited, only Khartoum and Juba were found to have organized systems of dumping waste into predefined moderately suitable locations. In all other cases, dumping took place on the outskirts of urban centers. Moreover, there was no waste separation at source, and slaughterhouse offal, medical wastes, electric and electronic, sewage and chemicals were seen within the normal waste stream. Waste was also commonly dumped directly into seasonal watercourses or rivers, thereby contributing to water pollution and waterborne diseases.

This paper presents the initiative of Integrated Waste Management Plan (IWMP) for Sudan in the context of assessing the sustainability of waste management alliances. IWMP differs from current conventional approaches towards waste management by seeking stakeholder participation, by including waste prevention and resource recovery explicitly, by encouraging the analysis of interactions with all urban of increasing population and economic development and by promoting an integration of different habitat scales (city, neighborhood, household). IWMP can be used as a policy tool and as an assessment/analysis tool. In this paper the emphasis is on its use as an assessment / analysis tool. It is expected that IWMP can be used as an assessment / analysis tool too for all aspects of the any waste disposal project cycle, especially for design / formulation, for monitoring and evaluation of future waste management project. Assessment of the sustainability of waste management means looking at waste management from three different angles: the perspective of stakeholders, waste system elements and sustainability aspects. The focus of this paper on the perspective of stakeholders in waste management and the contribution to sustainability of the alliances between stakeholders. It is concluded that the assessment process is not easy, but can provide valuable information about alliances and provide a basis for comparison. Needs for future action plan to develop the concept of IWMP as a tool for assessing the sustainability of waste management is indicated.

The IWMP requires guidelines to collect and assess the information on solid waste management practices including regulations and economic tools, institutions and resources, coverage of the services and technology, and role of various stakeholders. The goal of data collection on solid waste (quantification and
characterization of various waste streams) and existing management systems (collection, transportation, treatment, disposal, recycling and recovery) is to develop an integrated solid waste management plan. This initiative of IWMP targeted three perspectives, viz.: lifecycle, waste generation and waste management.

An IWMP should include the following elements:

1- Description of the community service area;
2- Description of the waste management program structure and administration;
3- Description of the current and proposed waste management practices;
4- Description of the funding, sustainability, and long-term goals IWMP
5- Documentation of approval of the IWMP by appropriate governing body.

The principles of the 5Rs hierarchy emphasize the value of waste as resources are:

1- Reduce waste at source
2- Reuse where possible
3- Recycle products at the end of their useful life
4- Recover energy or materials from the waste stream
5- Manage Residuals in an environmentally sound manner

**Materials and Methods**

Integrated waste management plan (IWMP) is a complex task. An IWMP involves various disciplines. Therefore strengthens, weakness, opportunities and threatens (SWOT) programme is followed to enhance decision making and taking concerning IWMP. A successful plan must include both short term and long-term goals. It must also provide a balance between three main factors: environmental regulations cost of running the plan, and community needs. To develop a plan one needs to comprehend the basic principles involved in managing each component and their effect on one another. For instance, if the ash generated by incineration of municipal waste tests out to be hazardous, then either the ash must be detoxified or it must be disposed in a specially designed landfill/landfill cell. Therefore, prior to including incineration in the plan, one needs to ascertain the characteristics of the incinerator ash so that correct disposal practice is included in the program. On a local or community level, IWMP essentially consists of the following five steps:

1. Waste source identification and characterization
2. Efficient waste collection
3. Reduction of volume and toxicity of the waste to be discarded
4. Land disposal or incineration of the waste past the reduction goal
5. Optimization of the first four steps to reduce cost and environmental impact

**Results and Discussion**

The initiative of Integrated Waste Management Plan (IWMP), in the context of the selection of technologies and the design of systems for waste management is vital. IWMP differs from the conventional approach towards waste management by seeking stakeholder participation, covering waste prevention and resource recovery, including interactions with other systems and promoting an integration of different habitat scales (city, neighborhood, household). The principles and mechanisms of IWMP are explained and their relevance for the technology selection and system design are outlined. It is emphasized that waste management is not a purely technical issue, but that other aspects need to be taken into account, while selecting a technology or designing a system, the political factor being the most important. Needs for future research to further develop the concept of IWMP are indicated, including identifying criteria for sustainability and defining weighting procedures. Waste management technology choices can be restricted to technical requirements like waste quantities and composition, area characteristics, haul distances to the disposal site and operational cost. It may be interpreted broader, including economic conditions, the cost of
labor and capital (interest rates, etc.), maintenance and repair capacity, and skill levels of existing staff. The concept of IWMP has been initiated by the author, as Advisor on Urban Environment and Development.

The different habitat scales that need to be integrated are the premise, neighborhood and city level. Table below shows the solid waste management activities that can be carried out at each of these levels.

Table 1. Habitat scales in an Integrated Waste Management Plan (CEDARE 1999)

<table>
<thead>
<tr>
<th>Habitat scale</th>
<th>Collection and disposal system</th>
<th>Resource recovery system</th>
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<tbody>
<tr>
<td>Premise level</td>
<td>Storage at source</td>
<td>Prevention</td>
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<td></td>
<td></td>
<td>Separation at source</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reuse at source</td>
</tr>
<tr>
<td>Neighbourhood level</td>
<td>Primary collection</td>
<td>Primary collection</td>
</tr>
<tr>
<td></td>
<td>Temporary storage</td>
<td>Sorting and pre-treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reuse</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recycling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Composting</td>
</tr>
<tr>
<td>City level</td>
<td>Secondary collection</td>
<td>Sorting and pre-treatment</td>
</tr>
<tr>
<td></td>
<td>Transfer storage</td>
<td>Secondary collection</td>
</tr>
<tr>
<td></td>
<td>Tertiary collection</td>
<td>Reuse</td>
</tr>
<tr>
<td></td>
<td>Final disposal and treatment</td>
<td>Recycling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Composting</td>
</tr>
</tbody>
</table>

IWMP can provide a framework for the selection of appropriate technologies for waste management and for the development of sustainable waste management systems in general, for both liquid (human) and solid waste. It can induce policy and institutional reform to promote sustainability in waste management. In addition, it can provide the basis for analysis of existing waste management systems to assess their sustainability. The concept can be used as a guideline for the analysis of the solid waste management system in Sudan. The financial aspects are expected to be facilitated by the multi-national donors. Furthermore The aspects of IWMP will be approached below from two different sides,

a. Principals guideline to achieve a integrated sustainable waste management system

b. Means/Mechanisms to be established to achieve this goal

IWMP Principals The following principles for Integrated Waste Management are recently initiated and developed by the author, based on needs assessment situation and the outcome of the suggested national strategy for environmental conservation (within environmental sustainability) compiled and edited in 2005 by distinguished national advisors.

1- Technical/Operational principles

2- Environmental principles of technologies and systems

3- Financial principles concerning management of technologies and systems

4- Socio-economic principles related to technologies and systems

5- Institutional/Administrative principles for introducing technologies and systems

6- Policy/Legal principles required for technologies and systems

Conclusion

Understanding of the magnitude of waste management problems, with their increasing pressures on the carrying capacity of Sudan will require constant monitoring, analysis and government support. All of this requires adequate equipment, sound expertise, effective policy instruments and a conscious public committed to reduction, reuse and recycling of waste. Against this array of forces, a determined effort to pursue improved management of waste through strategic interventions involving government, private sector and community initiatives to be undertaken by a quasi-statutory agency in Federal Government as early as
possible. The role can be played by this agency will provide a significant source of knowledge and expertise which are being drawn upon to assist all states in the Sudan. The implementation of the IWMP require a body of persons with the powers to make decisions efficiently and effectively regarding policy matters for the and an administrative system to all states in Sudan.

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References