Policies and Strategies for Sustainable Solid Waste Management in Urban Residential Areas – A Case Study of Kochi City, Kerala, India

Athira Ravi [#1], Subha Vishnudas [#2]

[#] Division of Civil Engineering, School of Engineering,
Cochin University of Science and Technology, Kochi, Kerala, India
[1] ravi.athira@gmail.com, [2] v.subha@cusat.ac.in

***Abstract*— In urban areas, the residential wastes contribute the lions' share of municipal waste. Managing these residential wastes is highly challenging as most of the developing countries do not have a proper waste management plan for their urban areas. The high organic and plastic content and the non segregated form of these wastes make them difficult to handle. Policies and strategies should be framed in such a way that, it must be suitable for the type of wastes generated in the area, nature of generation, characteristic of the area and other factors. This paper presents various policies and strategies for sustainable management of these urban residential wastes through a case study in Kochi city, Kerala, India.**

Keyword - Policies, Strategies, Solid waste management, Urban residential, Kochi

I. INTRODUCTION

The waste management strategies can typically be classified as working through command and control approaches, economic incentives and stimulation of innovation in the market place, and information and educational efforts (Sachs, 2006). Command and control strategies such as legislation and enforcement create a set standard and minimum guideline for all to follow. Many countries has passed a series of laws promoting the reduction and recycling of wastes including the basic law for promoting the creation of a recycling oriented society; the revised waste management law; the law for the promotion of effective utilization of resources; and the green purchasing law in Japan (Loughlin and Barlaz, 2006). Economic instruments have been shown to have a direct influence on waste management systems (Bilitewski, 2008; Skumatz, 2008) as well as recycling behaviour (Bolaane, 2006; Iyer and Kashyap, 2007) which is a critical component to waste management systems.

The success of any waste management plan will rely upon the cooperation of different stakeholder groups involved in the waste management. Monitoring is an essential component to the continued success and growth of the plan. It also allows the expected impacts of the strategy to be measured against actual changes, and this can inform future revisions of the waste management plan. Regular waste audits should be scheduled at least annually, but optimally at any time significant fluctuations in the waste stream are expected to occur throughout the year (CCME, 1996).

This paper presents the policies and strategies for sustainable solid waste management in the urban residential areas through a case study in Kochi city, Kerala, India.

II. METHODOLOGY

The waste management strategies recommended for sustainable solid waste management in the residential areas of Kochi city is divided under three heads; strategies for improving the biogas technology program, strategies for waste management of recyclables in residential areas and a generalized strategy for sustainable solid waste management in the residential areas of Kochi City.

Kochi city (formerly known as Cochin), lies between 9°48' and 10°50' latitude and 76°5' and 76°58'E longitude, Kerala, South India. It is the commercial capital of Kerala, 'The God's Own Country' and is in the Ernakulam district of Kerala. The Kochi Municipal Corporation extends to an area of 94.88 sq.km. As per census of India, the population of Kochi Corporation in 2001 is 5,95,575 and the population in 2011 is 6,01,574. The density of the city is 6,340 persons per sq. km against a density of 819 persons per sq. km in Kerala, 382 persons per sq. km in India and a world average of 46 persons per sq. km in 2011 (Census 2001, 2011).

For evolving the strategies for improving the biogas technology program which is widely practiced in the city as an organic waste management measure, a sustainability evaluation study was conducted for the technology using a conceptual framework evolved for sustainable domestic organic waste management. The strategies for waste management of recyclables were discussed based on the literatures and experiences from the different organizations practicing in this field in and around the world. Thorough literature review was conducted in order

to formulate objectives, targets and strategies for the waste management plan of Kochi city. For this, the works of Metro Vancouver (2010), Environmental Defense - McDonald's Waste Reduction Task Force (1991), Resource Recovery Fund Board (2008) , Nova Scotia Government (2010) etc. were reviewed in detail.

III. STRATEGIES FOR IMPROVING THE BIOGAS TECHNOLOGY PROGRAM IN RESIDENTIAL AREAS

From the sustainability evaluation study of biogas technology which was conducted among the existing users in the city, it was observed that, the biogas technology requires initial capital cost of installation which may not be feasible for low income groups. Therefore linking the biogas program with government initiatives is an essential strategy for improving the program. The outcome of the study also indicated that people are not aware of the standards regarding the quality, design, construction of the plant. To improve the quality standards there is high need for the modification of the design of biogas plants to suit the gas use pattern in the city. This will help in optimization of the plant and there by reduction in cost of installation. The plant owners in most of the cases are not able to carry out required maintenance of all defective parts on time due to technical and financial constraints. After sale service provisions therefore shall be viewed as major tool to preserve the interest of the users and safeguard the fate of the plant against any further deterioration.

There is high need of user's training on operation and maintenance of biogas plant to ensure the continuous functioning of biogas plant. Small scale industries shall be promoted for biogas construction. Private sector involvement shall be viewed as a means to develop a more productive and efficient economy and to increase the economic participation of the population.

In addition, the study reveals that the biogas technology has a number of synergies with other development sectors like health, women's development, agriculture and livestock management etc. These synergies can be utilized effectively if biogas technology is integrated functionally with other programs. It is therefore recommended that the biogas program is to be integrated with the women's development, agriculture, health and other rural development programs. There is an ample need to develop and establish linkages between potential stakeholders for program integration at the policy level. The participation of stakeholders varies from consultative, contributory, operational and collaborative depending upon the nature of tasks to be performed.

Efficiency and suitability of the present models of biogas plants was not conducted in detail in this study. Hence detailed study of the present model of biogas plants, prior to taking decision on the type and size of plant is to be disseminated. One of the factors observed during the field investigation is the improper use of slurry in most of the biogas households because of the ignorance of its potential. Hence training course for users shall be prepared and implemented on effective composting, handling and application slurry in the farms. Under sanitation programmes of the local bodies, people may be made aware of attaching toilet to biogas plants by highlighting the major benefits such as improvement in environmental sanitation in and around the house, production of more gas, elimination of harmful pathogens after digestion of excreta into the digester and enrichment of bio-slurry by added nutrient value.

Motivation is a vital component of any program like biogas that is aimed at a wider section of the population. Developing an effective motivation strategy will help in areas where people developed unfavourable attitudes towards the technology because of various reasons especially the failure of the existing plants. Similarly, in areas where the general awareness among the people on biogas technology is low or not existent, it is necessary to actively publicise it. The following could be some strategies for motivation in the context of Kochi city. The existing biogas plants have some positive impacts on the promotion and development of the technology which can be utilized for future promotional strategy. Motivation can be done through governmental and non-governmental officials. Local leaders, village heads, school teachers and other influential persons in the community could play an important role in selecting and motivating beneficiaries. School children could play the role of motivation worker. Subsidy can be provided for the needy and low income groups to attract more people to install biogas plant.

IV. STRATEGIES FOR SUSTAINABLE WASTE MANAGEMENT OF RECYCLABLES

Sustainable solid waste management aims to offer a chance to prevent waste through designs based on the full life cycle of the product, similar to natural cycles, which function without producing waste. Generally natural cycles are driven by the sun, which provides the energy for the system; the energy drives the photosynthesis process that orders atoms and molecules to higher value such as forest and food products. Dead matter is processed by microbes in the soil to become food for the next cycle. By this way, waste should, like any residue, be thought of as potential inputs for starting new processes. Waste materials that are generated must be recovered for reuse and recycling to reach the goal of 'using everything, nothing left'. In the waste management of recyclables sustainability is said to be achieved mainly through '3Rs', Reduce, Reuse and Recycle (McDonough and Braungart, 2002).

Among the 3Rs, to reduce waste means to avoid making garbage in the first place. This requires rethinking design for the total life cycle of the product and behavioural change in customers. Reusing an item means that it continues to be a valuable, useful, productive item, and replaces new items that would utilize more water,

energy, timber, petroleum, and other limited natural resources. To recycle is the act of processing used or abandoned materials for use in creating new products. Everything from paper, cans to electronic waste can be properly recycled. Recycling of wastes generated, is the thought of the day as many wastes are still dumped inside and outside the residential areas and people find it difficult to manage the same. The people cannot treat these wastes individually, but there are options if these are collected and segregated, recycling of all wastes can be a growing concern for an area. Certainly, the regulations as well as guidelines for waste recycling must be respected and adhered to strictly. However the first option, waste reduction has to be done in line with the present programs of recycling as all the reduction and reutilization is always easier than recycling.

A. Sustainable Management of Paper Wastes

Industrialized paper making has an effect on the environment both upstream (where raw materials are acquired and processed) and downstream (waste-disposal impacts) (Hershkowitz, 2002). Paper production accounts for about 35% of felled trees and represents 1.2% of the world's total economic output (FAO, 2004). There are a lot of options for reducing the amount of paper waste. Some of the options for reducing the quantity of paper waste are using both sides of paper, reuse of paper that is already printed on one side for documents like drafts, meeting agenda or temporary signs, book marking or saving the emails/web page in hard drives instead of printing, visual displays showing how to load paper to avoid misprints, utilization of size reduction features offered by many printers like duplex, booklet printing etc., use of two way or send and return reusable inter and intra office envelopes, using durable products instead of disposables like paper plates and cups, paper napkins etc. Recovered printing and writing paper can be used to make new recycled copy paper. Recovered paper can be used in a variety of other products as well. Recycled pulp can be moulded into egg cartons and fruit trays. Recovered paper can be used for fuel, ceiling and wall insulation, paint filler, and roofing. During the survey it was observed that the major share of the paper waste was newspapers, periodicals and the paper wastes generated by the school children. The children, parents, teachers and authorities should be made aware of any of the paper waste reduction techniques mentioned above.

B. Sustainable Management of Glass Wastes

The options for reducing the quantity of glass waste entering the waste stream is to go for sustainable alternatives like ceramic dishes and other kitchen wares and to refuse the disposable glass items and accept durable ones like refillable pens, fountain pens, mechanical pencils etc. All types of used glass containers can be reused indefinitely to make new glass products. It is actually easier to manufacture new glass containers from recycled glass than from raw material. Glass, especially glass food and beverage containers, can be recycled over and over again. In fact, 90 percent of recycled glass is used to make new containers. Recycled glass can also be used in kitchen tiles, counter tops, and wall insulation. Glass recycling has grown considerably in recent years through increased collection through curb side recycling programs and glass manufacturers' increased demand for recycled glass. Therefore proper collection of glass wastes from residential areas and effective recycling of glass waste shall be ensured for sustainable management of glass wastes.

C. Sustainable Management of Metal Wastes

The metals that we use in our daily life usually come in the form of steel, aluminium, scrap metal and others. The steel industry has successfully been able to reduce the amount of material needed to make the same products. Technological developments in gauge control are further reducing thicknesses from 0.20 mm to 0.12 mm. Steel for automobiles has also become more lightweight, especially given recent demand for lighter, more fuel efficient vehicles. It also is cheaper to recycle steel than it is to mine virgin ore to manufacture new steel (EPA, 2015). Recovering steel not only saves money, but also dramatically reduces energy consumption, compared to making steel from virgin materials. In turn, this reduces the amount of greenhouse gases released in to the air during processing and manufacturing steel from virgin ore. Aluminium can be recycled into a lot of different products such as tractor, trailer and car bodies; however, aluminium cans usually become new aluminium cans. Recycling aluminium does not reduce the quality of the metal, so it can be recycled indefinitely. Producing new cans from recycled aluminium saves 95% of the energy used to produce cans from ore, known as bauxite (Rousakis and Bernard, 1994). Lead can be recycled from old car batteries. Service stations and car battery retail outlets will generally accept car batteries for trade in, or take them to a metal recycler for recycling. The plastic coating found on some wiring can be removed by metal recyclers in a process called 'granulation' (Stensel et al., 2000). Collection and recycling of the metal wastes shall be initiated at local body level. These collected wastes shall be handed over to the local manufacturers on demand or may be handed over to agencies handling recycling of metal wastes in the country level.

D. Sustainable Management of Plastic Wastes

Plastics have substantial benefits in terms of their low weight, durability and lower cost relative to many other material types (Andrady et al., 2009; Thompson et al., 2009). Most types of plastics are not biodegradable (Andrady, 1994), and are in fact extremely durable, and therefore the majority of polymers manufactured today will persist for at least decades, and probably for centuries if not millennia. Even degradable plastics may persist

for a considerable time depending on local environmental factors, as rates of degradation depend on physical factors, such as levels of ultraviolet light exposure, oxygen and temperature (Swift and Wiles, 2004). There available a long list of alternatives to plastic (to reduce the use of plastics) we commonly use and might think we can't live without. The first option is to discard the items which contain plastic packaging. Another option is to use glass or steel containers, earthen cook wares, homemade reusable shopping bags, wooden/steel utensils for kitchen instead of plastic containers, plastic utensils, and plastic carry bags respectively. Next option is to buy in bulk bins as often as possible. Shopping from local farmers market is another option to reduce the use of plastic carry bags. These markets usually rely on paper packing. Carrying a container or a bag for purchasing meat/fish or other item can reduce the amount of plastic waste. The use of natural materials instead of plastics scrubbers and synthetic sponges is another option for reducing domestic plastic waste.

The use of biodegradable plastics (Smith, 2005) is another option for reducing plastic wastes. Recycling of plastics is one method for reducing environmental impact and resource depletion (Sinha et al., 2010). Energy recovery from waste plastics (by transformation to fuel or by direct combustion for electricity generation, use in cement kilns and blast furnaces, etc.) can be used to reduce landfill volumes, but does not reduce the demand for fossil fuels as the waste plastic was made from petrochemicals (Garforth et al., 2004). There are also environmental and health concerns associated with their emissions. One of the key benefits of recycling plastics is to reduce the requirement for plastics production. In terms of energy use, recycling has been shown to save more energy than that produced by energy recovery even when including the energy used to collect, transport and re-process the plastic (Morris, 1996).

Therefore the bottom line for sustainable waste management of plastic wastes in the city is to discard plastics and stick on to alternatives for plastics as mentioned above. Steps may be taken to collect the plastic already in the waste stream of residential areas and adequate measures shall be done to dispose the same with least environmental disturbances.

E. Sustainable Management of Hazardous and E-wastes

The quantity of hazardous wastes and e-wastes was of negligible value in the residential areas during the primary survey in 2010. So the quantity of these materials was not taken into account for segregation and the study. But nowadays, as we all know, electronics waste is becoming a major global issue (Chatterjee, 2012). Non rechargeable batteries contain harmful metals, so should never be thrown away with daily rubbish, they should be returned to manufacturer for disposal or recycled elsewhere. Rechargeable batteries are the most environmentally friendly option as can last for up to several hundred charging cycles resulting in less waste being produced. Some of the tips to reduce the quantity of e-wastes are use of second hand electronics, games, and toys, refurbished equipment from a certified e-steward, care full use of materials, avoid buying new CDs and DVDs since they are made from polycarbonate plastic, recycle old disks, choose healthier electronics, donation to charity and recycling printer cartridges really is worthwhile as cartridges can be expensive and remanufactured printer cartridges can cost as little as 10% of what original cartridges do. By lessening the amount of cartridges ending up in landfill sites, we are being kinder to the environment too.

F. Strategies for Sustainable Management of Recyclables

Sustainable waste management of recyclable wastes is possible by the active involvement of all stakeholders. A separate recycling department has to be constituted under the local self-government department. This department shall monitor, implement, and organize research and development activities for the management of recyclable wastes in the existing waste stream and also to suggest waste reduction techniques to avoid these wastes in future. Government should ensure people's participation in the waste management plan in order to efficiently handle and dispose the waste, as if they are the actual generators and end users. These will make the waste management plan more sustainable. Apart from the waste reduction and recycling options discussed in the previous sections, the following strategies are to be taken into account for the sustainable waste management of recyclables.

- Social responsibility – Active participation & perception of the people are the key factors towards deciding the apt measure to be considered for the preparation of a sustainable waste management for Kochi city.
- With a view to encourage and promote the maximum possible investment in waste management operation, government will have to look at ways and means to assist operators and individuals to embark upon a change programme that aligns with the national objectives of waste management. By providing incentives/rewards more people can be attracted to this field.
- As a society we need to be aware of the wide range of technologies available to address particular problems or particular waste streams. Research & Development initiatives shall also be encouraged which builds on the ability and knowledge of the society.
- The legal implication of our obligation to have a waste management plan which specifically takes into account waste minimisation issues is driven by the legal obligations. There is no doubt that we need stronger enforcement in this area in order to secure that the direction selected is met by all so as to achieve

convergence with our objectives. This will require administrative capacity building in the area but will also encourage those of good intentions to put forward self-regulatory regimes which may alleviate the administrative burden from within the public administration.

- Increasing public awareness on the need for sustainable production and consumption has to be encouraged by local authorities to organize collection of recyclables, encouraged some manufacturers to develop products with recycled content, and other businesses to supply this public demand.
- Economic instruments can take the form of taxes, while innovation can be stimulated through investments in program funding for emerging technologies.
- Signage is a critical component to waste management systems. Signage helps inform the public about what materials are acceptable for recycling and which are not and it can also encourage participation in recycling programs. The authorities can create their own bylaws regarding signage for sustainable waste management.
- Promote reuse of materials - Promotion of local level second hand markets related to the life style of human beings will be an attractive method for reuse of goods. A reuse cycle for human life has to be detailed for this. For example the crib which we buy in an infant stage shall be replaced by a study table in a childhood stage. In adolescent age, this will be replaced by a computer table. This will be replaced again by a wardrobe & crib and finally to a wheel chair or walking stick in old age. Hence second hand markets can play a major role in the reuse life cycle of human being. Therefore local merchants shall be encouraged to provide products based on this reuse cycle of human being.

V. STRATEGIES FOR SUSTAINABLE SOLID WASTE MANAGEMENT IN THE RESIDENTIAL AREAS OF KOCHI CITY

The various objectives formulated for sustainable solid waste management in the Kochi city are as follows.

(1) Minimize waste generation;
(2) Maximize reuse, recycling and material recovery;
(3) Develop waste management practices with people's participation;
(4) Adjust procurement policies;
(5) Develop educational programs;
(6) Ensure waste management is safe and effective and;
(7) Become a regional leader in waste management.

Table 1 shows the residential waste management plan for Kochi city which describes the objectives, targets and strategies for sustainable solid waste management in the residential areas of Kochi city. The initiation for implementation of the plan has to be started from country level to the individual level.

- Country level- Encourage and initiate Research & Development (R&D) programmes based on the tool ecological footprint analysis and develop country specific data sets and equivalence factors so that the footprint values will be more precise for the country.
- State level- A recycling department for the state should be established & there is a need to identify local bodies which offer less economic development and give offer to them to act as 'kidneys' of the rest of the population, without affecting the social life of the people but enhancing the economic development by processing the population's waste into valuable products like manure, recycled products etc. Invest in R & D to identify new uses for waste products & through market intervention to reduce the prices of recycled products are to be encouraged. The waste footprint model developed shall be make use of to assess the waste footprint of the population at individual level.
- City level - Create awareness among the population, enable reuse and recycling centres to reuse waste materials disposed of at these sites through the resale of reusable items, and sustain a give and take relationship with suburban local bodies, impose tax on people on the basis of volume of waste footprint values and offer incentives to households which produce less waste.
- Community level - Introduce a kerbside collection scheme for recyclables from all homes in the city, supported by a network of recycling centres for residents to drop off recyclable materials, communicate through residential associations the various effects of solid waste management problems, share new ideas and techniques of effective solid waste reduction and disposal methods.
- Household level - Promote home and community composting in the city through the provision of biogas plants and other apt technologies at low cost or with subsidies.
- Individual level- People should changes their approach towards the waste disposal and related issues in a sustainable manner. The individual should be aware that they are the generators and they can only solve the problem. Observe and compare the individual waste footprint regularly so that the individual can stick on to the techniques of waste reduction which offer low footprint values thereby less harming the environment.

TABLE I. Residential Waste Management Plan for Kochi City

Objectives	Targets	Strategy
(1) Minimize waste generation	Reduce the quantity of waste generated per capita Eliminate unwanted materials Systematize solid waste reduction and management practices into standard operating procedures and packaging/product specifications	Advocate for transfer of additional waste management roles and responsibilities to producers and consumers. Reduce or eliminate materials entering the solid waste system which hinder or limit the opportunities to achieve reuse, recycling, or energy recovery. Provide information and education on options to reduce waste. Evaluate shipping and packaging procedures to identify items which could be eliminated or reduced. Document details of the city waste stream and review regularly so that trends can be assessed.
(2) Maximize reuse, recycling and material recovery	Increase the waste diversion rate Use alternate materials which reduce production impacts. Substitute reusable items for disposable items in shipping, handling, storage and operations.	Introduce a recycling department for the city. Increase the opportunities for reuse and recycling and the effectiveness of existing recycling programs. Target specific materials for reuse, recycling and material recovery. Utilize non-recyclable material as fuel to provide electricity from waste-to-energy facilities. Develop reusable containers for shipping. Outline the roles and responsibilities of all stakeholders involved with waste management in recycling.
(3) Develop waste management practices with people's participation	Develop waste management plans in consultation with participant groups (working groups) and effective communication links. Work with regional organizations to minimize duplication of resources and facilities.	Create materials and tools to target community members and groups. Develop communication links between different groups involved in waste management activities by holding activity sessions detailing the importance of waste management and what people can do, which will avoid both gaps and overlaps in the plan. Identify options for cooperative product purchasing, including price and discounts for bulk purchases. Invite comment from regional organizations and businesses.
(4) Adjust procurement policies	Use the commitment to waste management as a lobbying point when pursuing funding for capital works. Support policies for reducing the front end of the waste stream. Develop regional alliances to maximize purchasing power and encourage waste avoidance specifications for products.	Develop purchasing guidelines consistent with the waste management strategy. Design tender specifications in such a way that those submitting tenders can address waste management issues. Identify regional bodies that have similar purchasing requirements.
(5) Develop educational programs	Involve the community Raise skill amongst waste management staff in the identification of opportunities for avoidance and minimization of waste currently being disposed of. Ensure that operational staff has the training to comply with relevant guidelines or legislation, and the support to report negative events or failures of the system.	Conduct awareness programmes, meeting specific information needs, and fostering a sense of community commitment. Conduct waste characterization studies to establish waste reduction goals. Track diversion progress and make information available Develop marketing program to attract regional organizations to participate
(6) Ensure waste management is safe and effective	Develop a combined environmental committee and health and safety committee Ensure compliance with waste management regulations Assign responsibility for the regular review of the available technologies for waste storage and disposal.	Document the segregation, containment, storage, collection, and disposal mechanisms for each category of waste, with particular attention paid to harmful categories. Develop accident response strategies for harmful categories of wastes and provide training for those who will be responsible for carrying them out. Provide staff training.

(7) Become a regional leader in waste management	Support regional waste management initiatives. Commit to environmental excellence beyond regulatory requirements.	Document a waste management wish-list that includes options, costs and benefits, and parameters that need to be met before each option can be actively considered. Advertise waste management initiatives. This should not be overstated and should include discussion of the limitations. Invite comment from regional organizations and businesses.

VI. CONCLUSION

This paper put forward the strategies for sustainable solid waste management in residential areas of Kochi city. The strategies were divided under three heads: strategies for improving the biogas technology program; strategies for waste management of recyclables in residential areas; and generalized strategy for sustainable solid waste management in the residential areas of Kochi city.

The strategies recommended for improving the biotechnology program were linking the biogas program with government initiatives, modification of the design of biogas plants, user's training on operation and maintenance of biogas plant, private sector involvement in all stages of construction and implementation of the plant, integration with the women's development, agriculture, health and other rural development programs, establishment of linkages between potential stakeholders for program integration at the policy level, attaching toilet to biogas plants under various sanitation programmes and finally awareness creation and motivation to the public.

The study also highlights the initiation of a recycling department in the state level as the first and foremost step for the sustainable waste management of the recyclable wastes. The department will monitor, implement, and organize research and development activities for the management of recyclable wastes in the existing waste stream and also to suggest waste reduction techniques to avoid these wastes in future. The waste management plan for recyclables will become more sustainable with effective people's participation, offering assistance to operators and individuals for investment in waste management operation, creating awareness of the wide range of technologies in recycling, provision of legal implication of the waste management plan. Promotion of local level second hand markets for recyclables, creating public awareness, provision of economic instruments like taxation and incentives, imparting proper signages to the recyclable and reusable products are also recommended as strategies for the sustainable waste management of the recyclables.

Finally the solid waste management plan for the residential areas of Kochi city was formulated with specific objectives. The objectives formulated were: minimize waste generation; maximize reuse, recycling and material recovery; develop waste management practices with people's participation; adjust procurement policies; develop educational programs; ensure waste management is safe and effective and; become a regional leader in waste management. Targets and strategies were formulated for each of these objectives in waste management plan. The plan implementation should be initiated at the country level and should extend to the individual level. Therefore strategies at country level, state level, city level, household level and individual level for the reduction of waste footprint and waste management issues in the city were suggested.

The paper concludes that integrated waste resource management planning enables local bodies to create a comprehensive strategy that can remain flexible in light of changing economic, social, material and environmental conditions. In many cases, the most efficient and cost effective way to manage waste is to not have to deal with it at all. Therefore waste diversion and waste minimization should be the primary focus for integrated waste management plans for local bodies. After implementation of the plan, waste audits are recommended for measuring the success and progress of the plan and to identify areas which require review.

Initiations at individual level are very much important in the case of solid waste management as they are the generators and end-users. The plan will work well with effective people's participation and motivation with adequate public policies. Each of the target and strategies formulated in the residential solid waste management plan of Kochi city can be individually taken for further detailed study. This provides scope for further researches.

REFERENCES

[1] N. Sachs, "Planning the funeral at the birth: Extended producer responsibility in the European Union and the United States", Harvard Environmental Law Review, 2006, 30, 51-57.
[2] D. Loughlin, and M. Barla, "Policies for strengthening markets for recyclables: a worldwide perspective", Critical Reviews in Environmental Science and Technology, 2006, 36, 287-326.
[3] B. Bilitewski, "Pay-as-you-throw - a tool for urban waste management", Waste Management, 2008, 28, 2759.
[4] L. Skumatz, "Pay as you throw in the US: implementation, impacts, and experience", Waste Management, 2008, 28, 2778-2785.
[5] B.Bolaane, "Constraints to promoting people centered approaches in recycling", Habitat International, 2006, 30, 731-740.
[6] E.S. Iyer and R.K. Kashyap, "Consumer recycling: role of incentives, information, and social class", Journal of Consumer Behaviour, 2007, 47, 32-47.
[7] CCME, "Waste Audit Users Manual: A Comprehensive Guide to the Waste Audit Process", Canadian Council Of Ministers of the Environment, Canada, 1996.
[8] Census Provisional Population Totals, India, Ministry of Home Affairs, Government of India, New Delhi, 2001, 2011.

[9] Metro Vancouver, "Integrated Solid Waste and Resource Management", Metro Vancouver, 2010.
[10] Environmental Defense - McDonald's Waste Reduction Task Force, "McDonald's Environmental Strategy", McDonald's Corporation - Environmental Defense Waste Reduction Task Force, 1991.
[11] Resource Recovery Fund Board, "Sorting It Out - A Guide to Waste Reduction, Recycling & Composting in the Food Service Industry", Resource Recovery Fund Board, Nova Scotia, 2008.
[12] Nova Scotia, "Government Environmental goals and sustainable prosperity act: Progress report 2010", Ministry of Environment, Nova Scotia, 2010.
[13] W. McDonough and M. Braungart, "Cradle to Cradle", North Point Press, New York, 2002.
[14] A. Hershkowitz, "Bronx Ecology", Island Press, Washington DC, 2002.
[15] FAO, "Trends and Current Status of the Contribution of the Forestry Sector to National Economies", Food and Agriculture Organization of the United Nations (FAO), United Nations, 2004.
[16] EPA, "Wastes - Resource Conservation- Common Wastes and Materials", U.S. Environmental Protection Agency, Washington, DC, 2015.
[17] J. Rousakis and A.W. Bernard, "Packaging, environmentally protective municipal solid waste management, and the limits to the economic premise", Ecology Law, 1994, 21, 947 - 1005.
[18] H.D. Stensel, and Coleman, "Technology Assessments: Nitrogen Removal Using Oxidation Ditches; Project 96-CTS-1", Water Environment Research Foundation, Alexandria, Virginia, 2000.
[19] A. L. Andrady and M. A. Neal, "Applications and societal benefits of plastics", Journal of Philosophical Transactions of the Royal Society B, 2009, 364, 1977-1984.
[20] A. Andrady, "Assessment of environmental biodegradation of synthetic polymers", Journal of Macromolecular Science, Part C: Polymer Reviews, 1994, 34, 25-76.
[21] R.C. Thompson, S.H. Swan, C.J. Moore, and F.S. Vomsaal, "Our plastic age", Journal of Philosophical Transactions of the Royal Society B, 2009, 364, 1973-1976.
[22] G. Swift, and D. Wiles, "Degradable polymers and plastics in landfill sites", Polymer Science and Technology, 2004, 9, 40-51.
[23] R. Smith, "Biodegradable Polymers for Industrial Applications", Woodhead Publishing Limited, Abington Hall, Abington Cambridge, England, 2005.
[24] V. Sinha, M. Patel, and J. Patel, "PET waste management by chemical recycling: a review", Polymers and Environment, 2010, 18, 8-25.
[25] A.A. Garforth, S. Ali, J., Hernandez-Martinez, A. Akah, "Feedstock recycling of polymer wastes", Current Opinion in Solid State and Material Science, 2004, 8, 419-425.
[26] J. Morris, "Recycling versus incineration: an energy conservation analysis", Journal of Hazardous Materials, 1996, 47, 277-293.
[27] Chatterjee,"Sustainable electronic waste management and recycling process", American Journal of Environmental Engineering, 2012, 2, 23-33.

AUTHOR PROFILE

Athira Ravi, Part Time Research Scholar, Division of Civil Engineering, School of Engineering, Cochin University of Science and Technology, Kochi, Kerala, India.

Subha Vishnudas, Associate Professor, Division of Civil Engineering, School of Engineering, Cochin University of Science and Technology, Kochi, Kerala, India.