Sustainable Organic Waste Management in Neighbourhoods Through Productive Urban Landscapes

P.K. Amritha and P.P. Anilkumar

Abstract In most developing countries, rapid economic growth and industrialization have transformed its landscape with significant effects on the environment. One major effect of this urbanization is the increase in waste generated and is more evident in developing nations since the capacity of these cities to collect, process or reuse and dispose solid waste is limited and is not sustainable. Disposing waste on land has been the most common and cheapest way of disposing it. But due to the uncontrolled dumping, the land has reached its carrying capacity which eventually affects the environment and its visual quality. Moreover, the quality of the wastes which has the potential for reuse in productive purposes is not considered.

In this paper, land (vacant land, open dumps/landfills) is considered as specific example case of urban landscapes which can be conserved and transformed to a productive space where organic fraction of the urban waste is processed and used for landscape development simultaneously. In addition to organic waste management the productive urban landscapes also contribute to a range of functions like food or non-food/ornamental crops for personal consumption or marketing purposes, nutrient recycling, biodiversity and visual quality that benefits the community. It also emphasizes the role of urban planners and landscape architects in ensuring that, when neighbourhood level plans are made and zoning is done, appropriate area is earmarked for such productive task, based on the number of household and the quantity of waste generated within an urban area. Thus, the paper explores the possibility of integrating the proposed facility into the urban fabric so that it is a multifunctional and a sustainable component which can be applied flexibly providing benefits to the people/community.

Keywords Productive urban landscape • Organic/biodegradable waste • Sustainability • Waste management

P.K. Amritha (✉) • P.P. Anilkumar
National Institute of Technology, Calicut, India
e-mail: amritha.pk@gmail.com

S.K. Ghosh (ed.), *Utilization and Management of Bioresources*,
DOI 10.1007/978-981-10-5349-8_9

1 Introduction

It is realized that there is a significant increase of solid waste generated the world over due to the increase in population, improved living standards, rapid economic growth and urbanization. In most cases, no segregation of waste at its source happens, or if segregation happens, then both biodegradable and non-biodegradable are mixed up at collection or at the disposal units. These units are usually open dumps/landfills, any vacant land or any other neglected area. This leads to deterioration of land and its resources and eventually gives rise to environmental degradation and health impairment. Moreover, such land areas which were originally located on the outskirts of any city has now shifted and become a part of the urban landscape as cities sprawl. Thus, they have largely manipulated the landscape of a city and have been converted to an unsightly land use which is often ignored.

In an Indian context, biodegradable waste constitutes major portion of the total waste. But when it is disposed along with non-biodegradable waste, their potential to provide nutrients for the plant growth which is an essential element of the landscape is less tapped or not tapped at all. A conceptual framework for identifying the waste category which has the potential for developing landscapes and to use the same for developing open spaces (as productive landscapes) in an urban area within a neighbourhood is the aim of this paper. The paper tries to integrate this aspect with a waste management policy which steadily facilitates a series of landscape development options and thereby redefining open spaces within an urban area using such nutrients from a sustainable/aesthetic perspective.

Nutrient part of the biodegradable waste can support plant life and thus become the base for developing productive landscape. For this, a clear and conceptually sound strategy needs to be evolved. This should also be based on the background of waste generation, its composition as well as the characteristics of the waste and the socio-economic context of the region. Further, the work proposes to do this based on existing literature-based inputs, field studies that explore deeper into the nutrient potential of the biodegradable waste to support plant life, identify feasible plant varieties and explore climatic congeniality to do this.

The current paper discusses the scope and feasibility aspects of implementing the concept of productive landscapes while planning and designing open spaces within an urban area. Through productive landscapes, the work simultaneously aims to develop green spaces which are used for growing food/ornamental gardens along with spaces within the city which manages its organic waste efficiently. Eventually the biodegradable fraction of urban waste adds to the aesthetic and visual quality of the urban landscape.

2 Review of Literature

There are many studies conducted connecting productive urban landscape development from the agriculture perspective. However extending this concept to urban landscape for managing the biodegradable fraction of the waste, there exist only limited studies. A pivotal/seminal work in this regard is the theoretical concept of CPUL (continuous productive urban landscapes) coined by architect Andrea Viljoen, to develop a network of productive open spaces which offers a space for growing food (Viljoen et al. 2005). This idea has inspired landscape interventions like the introduction of urban agriculture into the city fabric. Globally urban agriculture has evolved to meet the needs of the residents in the city. Most of the related examples were focused more on improving the livelihoods of the poor in the urban areas by providing food at lesser rates (Redwood 2009) and also giving job opportunities for the locals. 'Organoponics' is yet another attempt developed in Havana were raised beds were mixed with soil and organic matter which helped in the growth of food products. Such urban organic gardens first came up as a solution for the lack of food security. Many cities in developed countries have also recognized the extensive benefits of urban agriculture and planning or policy strategies which have been developed to support food production. Though the importance of food system through urban agriculture in planning has been recognized, very little research has been done in integrating functions like waste management by using the same space/land for both the purposes in a sustainable manner. The current paper is in this direction.

In India, 51 % of the total waste is organic in nature (Asnani 2006; Ranjith 2012). But most of these wastes (about 90%) are disposed without any proper segregation on to open dumps/landfills along with other wastes (Sharholy et al. 2008). At such sites, compaction, levelling of the waste and the cover of the waste, is rarely observed and is devoid of leachate collection, landfill gas monitoring and collection equipment (Bhide et al. 1998), unlike sanitary landfills. In a sustainable waste management, reduction, reuse and recycling of waste are most preferred options considering its environmental benefits (Asnani 2006). With regard to organic wastes, its segregation, decomposition and stabilization through different natural cycles form the basis of recycling. Treatment for organic waste recycling adopted in India is composting and anaerobic digestion. Composting involves biodegradation of organic waste into water, CO_2, energy and composted matter where the process is predominantly aerobic, and the waste volume is reduced to 50–85 % (Sharholy et al. 2008). Full-scale composting technologies are already demonstrated in many towns and cities. But their applications on landscape development are limited on account of poor marketing (Asnani 2006). It is said that only 9% of MSW is treated by composting (Gupta et al. 2007). Anaerobic digestion works out in the absence of air, where, anaerobic microorganisms act on the waste to release methane (which can be used as biogas for cooking), CO_2 and an organic residue which is a good manure. In fact, this process can occur naturally in a landfill/opendumps if the waste in it is not turned and aerated regularly. This condition if not controlled can cause

serious environmental issues. Researches in the field show that if there is enough space available, then aerobic composting is a better option (Sharholy et al. 2008). But one of the key issues that we face today especially in cities is the limited site availability for processing waste or for setting up new disposal sites (TERI 1998). Moreover, the capacity of existing landfills to hold more waste exceeds its limit calling for an upgradation/rehabilitation. Many rehabilitation projects have been reviewed where these dumpsites are closed and restored for some facilities or remediated to a controlled sanitary landfill (Sharma et al. 2004); not many studies have been explored in light of restoring a site so that the site continues as a disposal site and at the same time used for a different facility thus making it multifunctional.

The current paper looks into a framework where organic waste dumping on landfills/open dumps acts as a source for landscape development while conserving the space for further disposal and processing the waste and thus reusing it. Any upgrading measures must ensure that at every stage of the process, environmental issues and aesthetics are not overlooked.

3 Methodology

Organic solid waste in most cities is a significant and essential input for developing landscape since the widespread use of compost as fertilizer for plant growth has always been an accepted practice. Among the organic wastes, food wastes are always on the top of the list and are one of the major components of the waste generated in a household. The solid waste of organic nature generated in a household are usually collected as a larger system of solid waste management and are transported to some major dump locations within and outside the city, or it may be processed individually by each household in a home composting system. But all these processes seem to be not very conducive to maximize the utilization of the organic waste in developing productive urban landscapes. Along with utilizing the organic waste as a resource, the paper tries to look at the urban setting and its open areas/landfills as a resource to be tapped for developing productive landscape.

Urban landscapes are shaped by natural and social process that take place in an urban fabric. This makes it significant from all its perspectives, right from parks, private open spaces and recreational areas to, land used for dumping waste. As such, their locations and maintenance influence the built environment. Landfills which were located in the city outskirts earlier have now become part of the cityscape. But in most cases, improper treatment and maintenance of landfills have affected its visual stability making it an ignored and isolated part of the urban fabric which needs upgradation. This issue is more enhanced when there is a limitation in the site availability for processing waste or for setting up new landfill sites (TERI 1998) calling for an upgradation/rehabilitation. A thoughtful process of managing the potential organic waste of a city thereby recycling a major portion of MSW within the landfill site to create a distinctive urban landscape is challenging and promising at the same time. Any kind of upgradation measures must ensure that at every stage

of the process, environmental issues and aesthetics are not overlooked. In an attempt to conserve and develop urban open spaces and to simultaneously come up with a solution for disposal of urban organic waste from a landscape development perspective, the model (Fig. 1) explores alternatives such as upgrading existing dilapidated or unused open spaces to productive landscapes or creating new spaces for productive landscapes. Figure 2 shows the methodology for upgrading existing disposal sites for developing productive landscapes.

The municipal government is responsible for the waste collection, transport and disposal in most cities. It is observed that most often the authorities are unable to cope with the increasing demands in a formal waste management system, and this is specifically the case in India. This demands a decentralized yet innovative system for waste management. The conceptual model explained in this paper initiates a waste management strategy at a neighbourhood/community level. A neighbourhood level was mainly selected as a base since the scale of a neighbourhood can be very effective for land use planning and design to incorporate sustainability principles (Van der Ryn et al. 1986).

In short, to develop a productive urban landscape in a new site, a suitable patch of land needs to be identified within a neighbourhood considering the quantity of organic waste generated and the site conditions. The site needs to be divided into beds/pits of depth considering the ease of maintenance. The size of the pits is to be

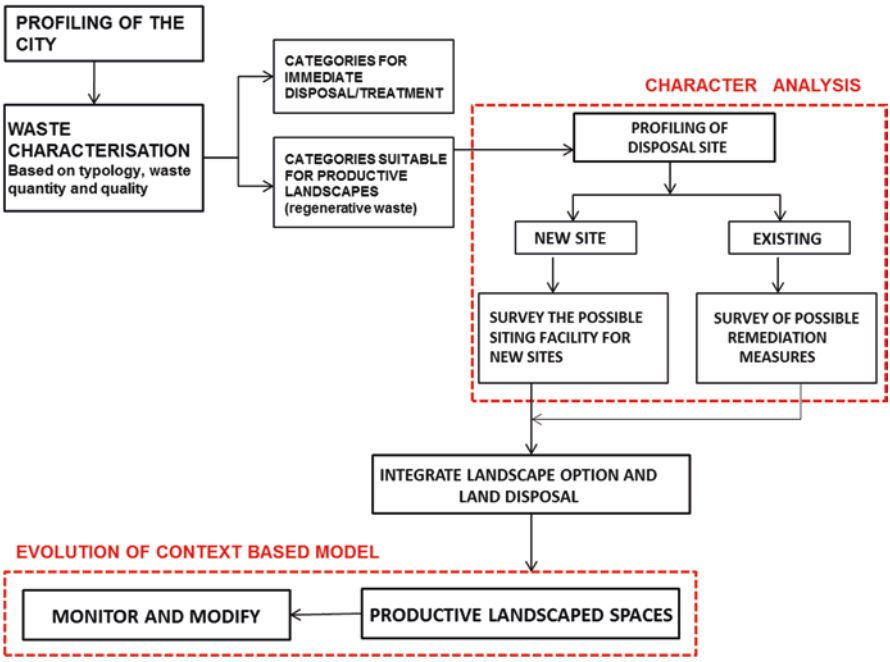

Fig. 1 Productive landscape – a conceptual model

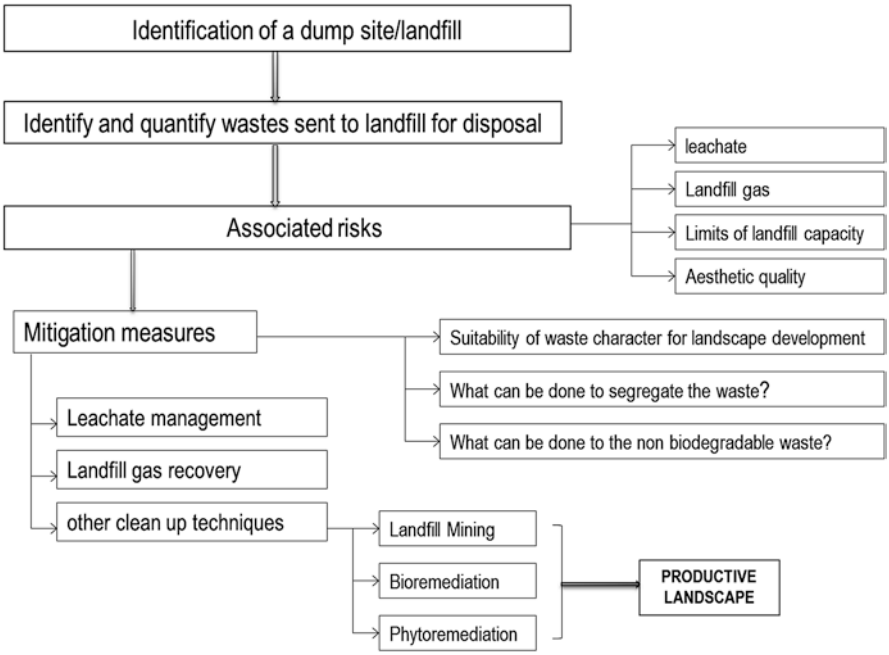

Fig. 2 Methodology for upgrading an existing disposal site

divided with respect to the plot size selected and the amount of waste diverted to it. Typically the whole process will undergo three different phases. It is briefly explained as follows.

Phase I (disposal phase) – in this phase, everyday kitchen waste was disposed in the designated beds/pits prepared on the land identified. Daily soil cover of soil, compost or any additives which can speed up the degradation can be added at this phase.

Phase II (degradation phase) – in this phase the contents in the beds/pits are kept open to degrade naturally. Frequent turning and breaking clods if any can be done in this phase. The degradation rate of the waste can be accelerated using additives. Once degraded, the substrate will be in the form of compost mixed with additives (if any added). Considering the waste settlement (which almost settles down to 50 %) which has happened in the beds/pits, the contents from one pit is transferred to another, and the emptied pit is used for disposing waste thus utilizing it for the second cycle of process.

Phase III (planting phase) – in this phase plants with suitable growth rate were selected and planted to utilize the nutrient content in the waste for their growth. It includes planting, irrigating, pruning, harvesting, replanting and monitoring the whole process.

As an output of the work, a database can be prepared that connects/correlates possible depths of the waste deposited, degradation time permitted and a range of

plant growth period (which helps in fixing the plant species) to the number of households and their expected quantity of waste generation within the neighbourhood premises. At the neighbourhood level, if these variables as listed are fixed/decided, the authorities can determine the area required for developing productive landscapes in a particular neighbourhood, and also it will help in determining the kind of plant species that can be selected depending on the area available and their growth patterns. The plants selected can be food crops or non-food/ornamental crops such as flowering plants for personal consumption or marketing purpose.

4 Discussions

To summarize, this paper explores the possibility of treating organic waste generated in a neighbourhood and its simultaneous use in urban landscape development by developing a concept called productive landscape. The waste settlement which can happen (about 40–50%) in the process of using only biodegradable kitchen waste can contribute in ensuring enough space to run the process in cyclic fashion where disposing waste and planting alternate. This in turn enhances the chance of development of a productive landscape that can be implemented as a continuous and sustainable process. Certain operational and maintenance practices (sorting, turning and compaction) helps to maintain an aerobic condition through which in turn reduces the particle size and thus making the degradation faster. This also helps to evaporate excess moisture which prevents leachate formation in most phases of the experiment. However during rainy season (high humidity), measures need to be taken to control leachate formation. A minimum slope should be provided to assist surface runoff and thereby to promote reasonable surface drainage. It is observed that this is very crucial as undrained water can increase moisture content thereby promoting leachate formation, and in most cases, this can adversely affect the plant growth. Moreover, the substrate needs to be fully decomposed, and there is a time required for this, and only after this, planting can normally be done. In a productive landscaped space, this period taken for the substrate to decompose fully can be utilized positively for abating/mitigating environmental impacts caused by excess leachate, odour or the stability of the substrate if any.

At the end of phase II, the refuse is in the form of stable compost. As per the research concept, the plant uses the fertilizer potential of this compost for its growth at the same location. It should be noted that additives like daily soil cover, compost (which can be externally added) or other additives such as coir pith, chemical inoculants, earthworms (vermicomposting), etc. could reduce the foul odour generated from waste. The framework proposed has to incorporate this measure in a sustainable way. Also it has been reported that the odour from an aerobic site is less pungent than compared to an anaerobic site. When the foul smell is reduced/avoided, other nuisances such as the presence of crows and dogs feeding on the waste also get reduced. To ensure avoidance of order problem, suitable cover provision also needs to be streamlined and systematically enforced. Also, the covering can help the

site during rains which otherwise increases the moisture content and eventually slows the degradation rate.

In phase III, fast-growing plants which are easy to plant and maintain and conducive to a given climate are only used. Care should be taken so that such plants do not over-dominate and restrict the growth of other plants on the landfill. In a productive urban space, to attain a cyclic process of disposing and developing vegetation, agricultural plants which give maximum yield in a shorter period (aiding crop rotation) can be selected. The remaining planting medium (soil/substrate) after harvesting can also be used as a daily cover during further processing or can be marketed. The proposed framework anticipates to utilize the service of a maintenance person periodically on site. Most of the points discussed here can be implemented through suitable instruction/training given to him.

As a result, a database can be prepared which can provide useful inputs to prospective local bodies/neighbourhood managers to determine the area required for developing the proposed productive landscape patch given other required essential parameters like depth degradation time and the plant growth period. It also explains the type of plants with respect to its growth period that can be chosen for the available space. To run the process in a cyclic fashion, you need to determine the number of days the waste is dumped in the subsequent beds till the first bed is used for the next cycle of dumping. The area requirement is calculated with respect to the amount of organic waste per person per day, the density of the waste as applicable to the study area and the number of days a bed requires to complete a cycle.

A cyclic process explained as a part of productive landscapes depends on the time required for the plant growth. So plant species which has a longer growth period is not suitable. A systematic selection of plants and understanding its growth regime will be part of the urban scale development of landscaped landfill. Selecting agricultural plants which give maximum yield in a shorter period of time thus aiding crop rotation can be selected. Climate is yet another determining factor of the decomposition process. But how exactly the seasonal changes influence this process in different soil conditions can be an area for further research to be conducted. Another limitation is the scarcity of land in urban areas which are suitable for this process based on its location, size and proximity to other resources (like water, solar access and a well-drained soil). Moreover, the issue of scarcity of land aggravates further when the proposed productive function competes with other commercial developments which provide more profit out of the same land. This aspect of the problem can be resolved by educating the public about the wide range of benefits from productive landscapes and their integration with waste management in the urban areas. While the proposed function is best implemented through community-based approach, there is a need for continuous monitoring of such spaces, and that requires a caretaker/maintenance system with an operational cost. The knowledge and skills necessary to manage these systems for multiple functions need expertise on environmental, social and economic aspects of management of the waste mentioned.

5 Conclusions

In many cities, the unsegregated waste that is disposed on land has become a serious threat causing health and environmental risks and landfills/open dumps or any vacant lands, which are used for disposing of waste, hitherto are turning out to be more of an environmental hazard. From the perspective of the concept discussed in this paper, such spaces need to be decommissioned and need to be transformed and upgraded to a productive land parcel of greater utility for the urban population. The paper proposes a methodology for such spaces and other new open spaces available to be made productive by implementing environmentally sound and sustainable strategies for disposing the major portion of municipal solid waste (which is biodegradable in nature) and utilizing the same for landscape development. Such productive spaces within an urban fabric can add aesthetic value and support/supplement economy (through landscape/food/manure production) and will eventually take the city's people closer to a self-sustained community.

References

Asnani PU (2006) Chapter 8. Solid waste management, India Infrastructure Report, 160–189

Bhide AD et al (1998) Solid waste management in Indian urban centers. Int Solid Waste Assoc Times ISWA 1:26–28

Gupta PK et al (2007) Methane and nitrous oxide emission from bovine manure management practices in India. J Environ Pollut 146(1):219–224

Ranjith KA (2012) Sustainable solid waste management in India. M S thesis, Earth Engineering Centre, Columbia University, New York

Redwood M (2009) Agriculture in urban planning – generating livelihoods and food security. Earthscan, London

Sharholy M, Ahmad K, Mahmood G, Trived RC (2008) Municipal solid waste management in Indian cities – a review. J Waste Manag 28:459–467

Sharma HD et al (2004) Geo environmental engineering: site remediation waste containment, and emerging waste management technologies, Chapter 24: End uses of closed landfills, Wiley

TERI(earlier Tata energy research institute) (1998) Solid waste management in India: options and opportunities, Report

Van der Ryn S et al (1986) In sustainable communities- a new design synthesis for cities, suburbs and towns. New Catalyst Books, Gabriola Island

Viljoen A et al (2005) CPULS: continuous productive urban landscapes – designing urban agriculture for sustainable cities. Elsevier, Amsterdam